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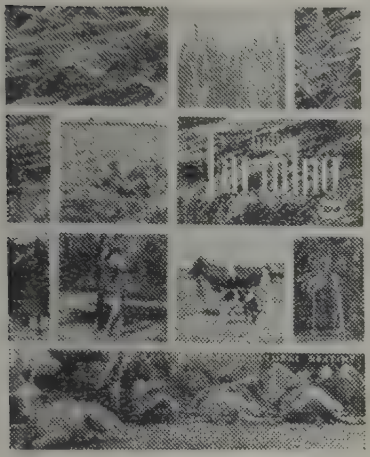

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Editor's page

Let us Dedicate Ourselves

On this auspicious occasion of the twenty-fifth year of our Independence, our thoughts go to the martyrs who enabled us to celebrate this occasion. We bow our heads.

From the very beginning of the struggle there was an emphasis on the economic content of freedom. All those evocative outpourings from the Mahatma on what Manchester and Lancashire had done to India, the equally evocative expression 'Grama Swaraj' so dear to him, were all intended to convey what the Mahatma meant by freedom to the people—a life free from exploitation and a life full in the sense of freedom from hunger and freedom from the endless anxieties caused by deprivations of all kinds. Have we today a sense of achievement on these tasks of destiny ?

Yes, in a sense. The great infrastructure for growth, for battle against poverty, was laid by the late Pandit Jawaharlal Nehru. He was the dreamer, the architect of our plans. He foresaw clearly the role of science in shaping the destiny of an underdeveloped country like India. Our irrigation projects, our steel plants, our great laboratories and institutions of research, all these bear the stamp of his immortal genius. And today, his daughter Srimati Indira Gandhi is pursuing his policies with the zeal of a crusader, adding whole new dimensions, shaking the vested interests as they had never before been shaken. All true activists and thinkers are thankful to her.

But let it not be forgotten : ending poverty from the homes of nearly 600 million people is not an easy task. The benefits from the types of plans with which we are familiar will not easily percolate to the villages and hamlets. For that there should be a plan for every village. There should be a plan for every home. You would be asking in surprise : what is a national plan for every home? It is simply this. Every citizen when he takes up a job should consider this : in addition to bringing up my family, what is the quota of benefit to the country from the job I am handling? This would make every scientist a nation-oriented scientist, every engineer a nation-oriented engineer, every teacher a nation-oriented teacher, every merchant a nation-oriented merchant, every clerk a nation-oriented clerk. A village plan will then be only an extension of this idea—how do we all together raise the status of the village? Thus will India grow, the only answer to our regional disparities. This will call for skilled actions, millions of individual skilled actions, with science and technology as the base. This aspect of our planned growth demands further study and research.

Agriculture is our, we mean the Council's, special field. Every agricultural scientist, the moment he sees an ill-nourished, underfed child, should pause and shed a tear of atonement. Because, vicariously, he must bear part of the responsibility. It is his duty to end such a state of affairs quickly. And in this task he has the whole great farming community as his allies. Have they not rallied to the call of science? That means, the agricultural scientists have a role of destiny today. And we are sure, they are conscious of it.

Yes, we will shape a new India. That is the homage we pay to the martyrs.

we have not done badly but MUST DO BETTER

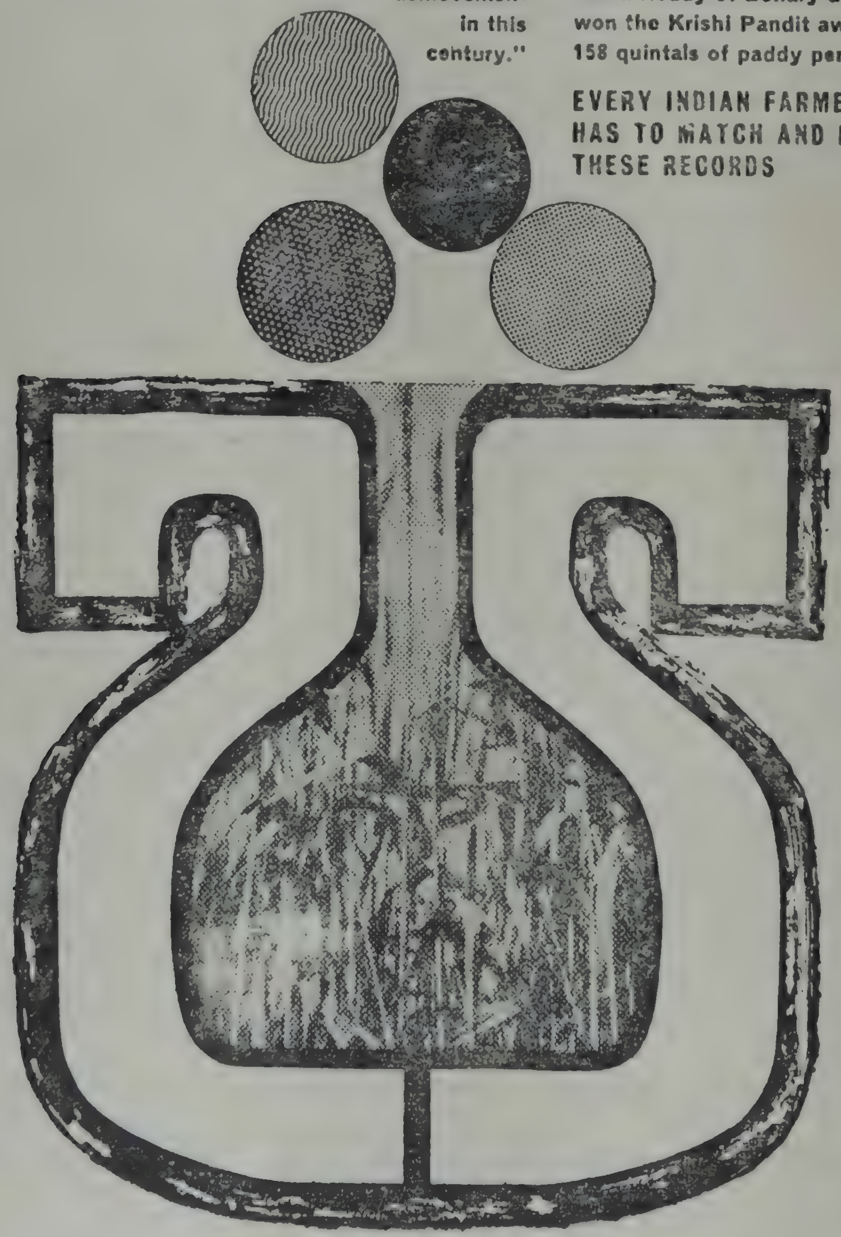
In the epoch when we were not free, famines were frequent and as recently as in 1943, four years before independence, took a toll of three million lives in Bengal. There were prophets of pessimism all over the world when the rains failed for two years in 1966-68. But the world Press later referred to the Bihar drought as "the famine that wasn't."

We have not done badly in the twenty-five years of freedom. We drove towards self-sufficiency through our Green Revolution, which has been hailed by the world Press as "an accomplishment that may be as important for the human race as any other achievement in this century."

We decided we would stop concessional food imports by the end of 1971 and did, though we had to look after ten million unexpected guests from Bangla Desh for the best part of an year.

Krishi Pandit Ramesh Rajabhau Bondre of Buldana district, Maharashtra, achieved this high score in wheat production—161 quintals per hectare. Malla Reddy of Bellary district, Mysore, won the Krishi Pandit award by getting 158 quintals of paddy per hectare.

EVERY INDIAN FARMER HAS TO MATCH AND BETTER THESE RECORDS



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AGRICULTURE TOMORROW

FAKHRUDDIN ALI AHMED
Minister for Agriculture

In what direction should our agriculture move hereafter? Population is steadily increasing. Agricultural land is shrinking. Already a country of small holdings, and with active steps under way to enforce land ceilings, how can collectivisation of management be harmonised with individuality of ownership? In a thought-provoking speech, Shri Fakhruddin Ali Ahmed, Union Minister for Agriculture threw light on all these issues—the vision for tomorrow in the light of the realities of today—addressing the annual general meeting of the Indian Council of Agricultural Research held in New Delhi on 10th May 1972. The following are major extracts from the speech.

THE year under review is one of great significance in our agricultural history, since the dream of self-sufficiency in food production is at long last becoming a reality. It would, therefore, be timely to ask ourselves the question: in what direction should our agriculture move hereafter?

Obviously, with a population which will exceed 600 million in a few years, a relative stability in food production and a substantial buffer stock storage are essential requirements for warding off hunger and famine for ever. Once the production potential of our agriculture has been raised, the consequences of weather-induced fluctuations in total production can be faced without undue difficulty through appropriate changes in crop planning. The most important characteristic of the agricultural scene of tomorrow should be stability of production, utritional adequacy, agrarian prosperity, productive employment, national self-reliance and above all, the harmonious co-existence of plants, animals and man in a mutually symbiotic and permanently productive bio-system.

Vision for Tomorrow and Realities of Today

We have to view this vision for tomorrow in the light of the realities of today. First, land is going out of agriculture every day due to the spread of industry, roads, houses, salinity and alkalinity and various forms of erosion. At the same time, population is growing at about 2.5 per cent per year, thereby making imperative the production of more and more food from less and less land. Steps to banish protein calorie malnutrition are particularly important.

Secondly, the very tools of modernisation of agriculture such as pesticides and fertilizer, when improperly applied, result in adverse effects on the health of man and animal and threaten long-term productivity. The realisation that man is part, not only of a human, but of a natural and biological community and that he has important responsibility in this respect should be the foundation on which the future research and development strategy should be erected.

Thirdly, developments in industrial design tend towards replacing man with machine, consequently placing the onus of providing employment largely on agriculture and agro-industries.

Fourthly, synthetic substitutes for crops like cotton and jute are being rapidly found and popularised. Both these crops involve labour intensive management and, in addition, cotton is a very important cash crop of the semi-arid areas. This would imply that in crops like cotton we should have a national policy prescribing the relative proportions of natural and synthetic fibres that should be produced and the varietal composition that should be adopted for meeting the needs of each staple length and spinning quality category.

Fifthly, the rapid development of agricultural technology in all developing countries necessitates a careful reviewing of trade patterns, market trends and export possibilities. Research on all aspects relating to export promotion should be carefully dovetailed to such analysis.

Sixthly, a major spurt in research in the fields of animal husbandry and fisheries is necassary.

Finally, while the farming technology gets growingly sophisticated requiring a coordinated application of knowledge and physical inputs as well as a cooperative crop management strategy on the part of entire village communities, the existing pattern of education has proved to be by and large inadequate, both quantitatively and qualitatively. One of our immediate needs is to gear the educational system to catalyse a movement for collectivisation of farm management without affecting individuality of ownership. To achieve all these aims, a careful blend of transfer, adaptation and innovation in technology will have to be aimed.

Until the formulation of the Fourth Five-Year Plan, Plan provisions and programmes in agricultural research did not constitute a separate Head of Development. At a late stage, in view of the growing and critical importance of agriculture research and education, it was considered cogent to provide for a separate Head of Development in that Plan document. However, such an arrangement was confined only to provisions in the Central Sector. In fact, agricultural research and education, which are State subjects and for which there is a considerable financial provision in State sector could not be reflected.

Exploratory Research

I need hardly emphasise that scientific research has emerged as the major source of agricultural growth in modern India. The process of creation and adoption of new technology consists of developing and learning how to use a whole new set of inputs that are highly productive. New inputs may be in the form of new crop varieties that are highly responsive to increased amounts of fertilizer, new breeds of strains within breeds of livestock and poultry that are highly efficient converters of feedstuffs into food; new machines or radical modifications of old machine that substantially enhance the efficiency of the human and animal power component of production or permit new operations previously unachievable or new systems of production that change the timing and sequence of new or old inputs or the combination of these. A selfsustained process of technological change as a critical factor contributing to agricultural growth calls for:

(a) availability of new technology that is highly productive and profitable compared with the technology and personnel in use at a point of time; and

(b) a process of continuous development of even newer technology together with attendant scientific manpower at a pace matching the rates at which the economic benefits of the most recently adopted technology are exploited.

An accelerated pace of growth of the R and D development complex for agriculture involves new thinking, new ideas, dynamic planning and a heavy accent on exploratory research. Indeed, the last one is most critical as it should envisage and consist of schemes and programmes which distinctly prepare for the future. On the realistic assumption that the present will work out their effects in a few years' time, maintenance of a continuous rate of growth in agriculture would require exploration of new avenues of improvement. Unless preparation for this is made within the planning process by envisaging and laying down a number of exploratory research schemes and programmes in a variety of directions at every stage, we may soon be reaching a plateau.

Forums of Integrated Research

The I.C.A.R. is currently supporting research, teaching and extension education programmes in agriculture, animal husbandry and fisheries through a national grid of All-India Coordinated Research Projects. These projects have become excellent examples of the value of cooperative endeavour among scientists belonging to different disciplines and different administrative set-ups. Sixty-nine such projects are now in operation bringing together thousands of scientists into a common forum of integrated activity on research problems of immediate relevance to our economy. There is probably no other example in the world of such a vast network of coordinated projects. The other important activity of I.C.A.R. has been extending help to State Governments in establishing agricutural universities. During the last year Agricultural Universities were founded in Kerala, Tamil Nadu and Gujarat. Maharashtra will now have three Agricultual Universities. The Government of Jammu and Kashmir is also contemplating to establish an Agricultural University in that State with a horticultural bias. Obviously, these universities are in various stages of development and require different orders of assistance both qualitatively and quantitatively. In pursuance of our policy of self-reliance and the building up of our own national capabilities in institution building, the I.C.A.R. has formulated a project whereby the services of Indian scientists and experts can be made available to different Agricultural Universities to help in specific tasks. A national training centre for project formulation has also been set up at the Indian Agricultural Research Institute in order to train senior State officials in the technique of project formulation both for national and international support. I hope all State Governments would ensure that adequate financial support is available to the Agricultural Universities serving their States and that close linkages between research, education and extension are developed and maintained.

The various I.C.A.R. Institutes have continued to make important contributions in different fields as would be clear from a perusal of the Annual Report of the Council. In addition to supporting Agricultual Universities, I.C.A.R. Institutes and All India Coordinated Research Projects, the Council has also supported from its cess funds a large number of *ad hoc* research projects submitted by different institutions and universities in the country.

It is our hope that in the coming years we can play a leading role as a partner in international agricultural development. We have entered into cooperative agreements with the U.S.S.R. and the Arab Republic of Egypt for close cooperation in various fields of research and development pertaining to agriculture, animal husbandry and fisheries. The I.C.A.R. has also been entrusted by the Government of India with the responsibility of helping to establish an International Crops Research Institute for the Semi-Arid Tropics at Hyderabad. The Andhra Pradesh Government has kindly donated 1,200 hectares land for this International Institute whose constitution has been signed recently by the Food and Agriculture Organization of United Nations and the International Bank for Reconstruction and Development. This is the sixth in the chain of International Research Institutes. Members may be aware that the other five Institues are located in Mexico, for Wheat and Maize, Philippines for Rice, Peru for Potato, Nigeria for Humid Tropical Agriculture and Colombia for Tropical Agriculture. All these institutions are now receiving multi-lateral funding through the Consultative Group for International Agricultural Research sponsored by Food and Agriculture Organisation, United Nations Development Programme and World Bank. I have little doubt that the new International Institute now in the process of establishment at Hyderabad will mark an important milestone in man's quest to conquer the adverse effects of low rainfall on cropping. This Institute will further strengthen the work already under way under the All India Coordinated Dryland Improvement Project which is being implemented with assistance from Canada.

It will be our endeavour to try to take advantage of assistance and collaboration from all friendly countries in strengthening our agricultural research and training programmes. We are hoping to start soon with help from the United Kingdom an unique project for maximising the production of black cotton soils near Indore. We are also in the process of launching a major drive in the field of integrated pest control in rice, cotton, sugarcane, groundnut and coconut. This project will aim to make use of biological control methods, radiation sterilization techniques and genetic and agronomic approaches, in addition to using chemical pesticides. The aim is to minimise the use of chemical pesticides and in this task the Indian Atomic Energy Commission and the United Kingdom Government will also collaborate. A similar project on the biological control of water hyacinth and *salvinia* which have become great menaces in our waterways in States like Bengal, Orissa and Kerala, is proposed to be initiated with the association of the Commonwealth Institute of Biological Control at Bangalore.

Collectivisation with Individuality

One of our major requirements now in the field of training is to develop a new class of agricultural graduates who can catalyse cooperative endeavour among small farmers. Members are aware that ours is already a country of small holdings and that active steps are under way to enforce land ceilings. It is therefore imperative that we try to develop a collective management philosophy and technique which, while enhancing the efficiency of our agriculture, does not interfere with ownership rights. Collectivisation of management with individuality of ownership is a goal which requires for its accomplishment a large number of well-trained technical persons who can demnostrate effectivey the value of cooperative endeavour in fields like water management, pest control and post-harvest technology. The I.C.A.R. with the help of Agricultural Universities is planning to sponsor training courses for agricultural graduates specially designed to equip them to launch this movement. I am convinced that unless this is done we will not be able to make much headway in converting the scientific breakthrough already accomplished in crops like rice, as well as in areas like cattle breeding and fish rearing, into production breakthroughs.

The first line demonstration programmes like the National Demonstration project and the rice mini-kit programme have been further intensified. For Example, during this year about 33,000 demonstrations with fine grain, high-yielding varieties and 10,000 demonstrations with gall midge resistant varieties have been laid under the rice mini-kit programme in farmers' fields.

You are all aware that in spite of all efforts on the part of Central and State Governments, the number of persons who are illiterate is still growing in our country. Therefore, in addition to other forms of educational programmes we need also a massive technical literacy drive. For this purpose the I.C.A.R. is planning to establish a few Agricultural Polytechnics soon.

The present phase of reorganization of the I.C.A.R. in order to make it an effective instrument of servicing and coordinating agricultural research and education started in 1965. This process is however yet to be completed by giving proper definition to the nature and type of organization which is best suited to the needs of agricultural science and education. We are hoping to take a decision soon in this matter. We are also grateful to Justice Dr P.B. Gajendragadkar and a few other very eminent scientists, educationists and administrators for giving their valuable time to help us in improving our personnel policies. I am confident that the report of the Dr Gajendragadkar Committee would be valuable in making I.C.A.R. into an even more effective and well-organized instrument of service to our people.

DEVELOPING AGRICULTURAL TECHNOLOGY IN INDIA

A. P. SHINDE
Minister of State for Agriculture

We know that large parts of the world are having difficulties in feeding themselves. This is because the problem of increasing food production is very complex. Otherwise, most of the countries, which are unable to produce enough food in spite of extensive areas under cultivation, would have been producing foodgrains in abundance. This somewhat unsatisfactory situation is true particularly of many of the developing countries. In these countries insufficient production is due, in a large measure, to the poor capacity of the farmers to invest money on production requisites which have to be purchased, if yields are to be increased substantially. In absence of investment capacity the farmers try to make do with inputs available on the farm rather than purchased inputs, and this tends to make agriculture in these countries tradition bound and primitive. Even where investment could be made on purchased inputs it has often been found that technology developed elsewhere could hardly be successfully applied in agriculture due to the great complexity of factors affecting crop production. An idea which has worked well elsewhere may not work well when tried by another country. There may be an excellent crop variety or a method or technique of growing a crop in a country but if it is introduced in another country it may need a change in the whole constellation of factors which must be used in the best possible manner in order to ensure success of the introduced idea or technique. Often times, it does not succeed at all.

Progress slow with traditional agriculture

The problem facing Indian agriculture was made more acute with the partition of India in 1947 when about 30 per cent of the irrigated area went to Pakistan along with large areas producing a substantial portion of the cotton and jute crops on which the Indian textile and jute mills depended. Although long tradition of growing the many crops cultivated in India had resulted in a technology which could be considered dependable for ensuring a certain level of production, and was perhaps among the best that could be recommended under the conditions of farming in vogue, departure from traditional practices was necessary if the country was to increase its production of food and commercial crops. Native varieties, although well-adapted to local soil and climatic conditions, could not show high response to fertilizer use without suffering from lodging and consequently resulting in loss to the farmers. Varieties introduced from other countries were not sufficiently well-adapted to local conditions to provide an answer to the problems besetting Indian agriculture. Therefore, much of the increase that took place in the early years after independence resulted from increasing the area under cultivation through major, medium and minor irrigation projects for which the country invested several billion rupees. A steady rise in the price of agricultural products resulted in many areas, which were formerly left fallow, being brought under the plough. The yields from these somewhat marginal areas was small but due to large additional acreages having come under the plough they were also able to contribute in a fair measure to the total production. On an average the increase in production was of a level of about 3 per cent a year. But most of this increase was due to expansion of cultivated acreage rather than to increase in productivity.

Research helps farmers adopt fertilizer use

Agricultural research, which had been initiated in the country almost with the beginning of the century and which was being carried on at a number of research stations administered by the Government of India as well as by various State Governments, began to make its impact on production within a decade of independence. This was due mainly to the large scale programme of simple fertilizer trials conducted on the fields of farmers in order to verify the results of fertilizer trials that had been conducted at the several research centres in earlier years. The results were so revealing that a programme of fertilizer demonstrations, involving several thousand demonstrations every year, was taken up in the middle of fifties. The result was that for the first time millions of farmers, who used to depend on traditional farm yard manure or compost and, to some extent, on oilcakes for improving their crops yields, began to develop an awareness of fertilizer use. In spite of a prejudice that fertilizers were not good in the long run for the soil, the consumption of fertilizer went on increasing fast and is now about fifty times more than what it was 25 years ago.

The Many problems of Indian Agriculture

The Government of India, conscious of the many problems of Indian agriculture, had been fixing priorities for improving farm production. Thus inputs in agriculture had to be increased, like fertilizers, plant protection chemical and equipment, improved farm implements, good seed, etc., besides credit which was needed in large amounts by farmers most of whom were too poor to purchase their production needs without credit. But one of the greatest priorities was the need for reaching 60 million, largely illiterate, farmers in order to communicate new technology which was necessary for increasing crop production. Need was felt also for increasing production of livestock and their products and therefore the task of improving agricultural production was very formidable. Added to this the problem of improving Indian Agriculture is more comlicated and costly because grain production and seed improvement involves a very large number of grains produced in the country. Unlike some of the advanced countries, which had to concentrate only on one crop like wheat or rice, in India crops which are important both as foodgrains as well as commercial crops number about one score at least. There is demand from farmers and their representatives for research on all these crops and the efforts made for intensifying research on all these crops have been very commendable.

Extension Service Set-Up

Several Committees went into the question of the problems which faced agriculture in India so that they could be solved with the resources available with the country. Among these problems are those relating to credit, land tenure, price fluctuation, irrigation, soil and water management, and agricultural education and research. Since the most important single factor in improving agriculture is the farmer himself, it was necessary that the needed change in the attitude and decisions of the farmers is brought about in order to help him use the new knowledge and use the inputs profitably in his production programmes. To bring this about, an adequate extension set-up had to be provided first. This was done by dividing the country into about 5000 Development Blocks, each provided with an extesion set-up consisting of subject matter officers relating to agriculture, rural industries and so on. They operate through Village Level Workers. Each Block covers an area having a population of about 60 to 70 thousand persons. Initially, the number of Village Level Workers in each was 10 and it required about 10 years to open the needed number of Blocks during which period a large number of training institutions had been developed to provide training to the extension workers before they could assume their field responsibilities. Experience with progress in the programme shows that the farmers in India, as perhaps elsewhere, can move very fast, and demand for new technology has led to the realisation that the number of extension workers required, and the intensity of extension set-up and efforts needed in order to keep pace with the demands of farmers for extension, is many times more than what was originally provided. Hence a selective approach is now being developed whereby selected areas are chosen for intensive extension programmes which are now operating in different states.

Reorganization of Agricultural Education and Research

Lately, considerable impact on the agricultural production programme has been made by the reorganisation of agricultural research and education. The contribution of research to improvement of production through the agronomic experiments conducted with fertilizers has already been mentioned, but much more improvement was needed in order that the traditional varieties could be replaced with varieties which are as responsive to fertilizers and favourable conditions of growth as is enjoyed by farmers in advanced countries. To breed such varieties a considerable change in the existing organisation of research became necessary. As a result the Indian Council of Agricultural Research, which was established in 1929 (then named as Imperial Council of Agricultural Research), had been attempting to promote and coordinate research on a variety of crops and agricultural and livestock problems all over the country. But it hardly had any research institution of its own. The research institutes established by the Government. of India were operating under the administrative control of the Department of Agriculture of the Ministry of Food and Agriculture, and the many projects dealing with commercial crops were financed and administered by a number of Commodity Committees which functioned independently of one another and of the ICAR. The States had their own research organisations and agricultural colleges but these suffered from insufficient integration between teaching research and extension. Therefore, organisation was needed in the States as well as at the centre. The problems were examined by various Committees between the years 1954 and 1963 in which Indian as well as foreign experts were represented. As a result of the recommendations of these committees several changes in the agricultural set-up have been introduced in the country. Agricultural Universities have now come up in all the States. The idea was first contained in the Report of the University Education Commission headed by Dr S. Radhakrishnan and supported by the expert committees which examined the problems of Indian agriculture in subsequent years. These Universities aim at complete integration of teaching, research and extension which would make teaching more practical, research more meaningful, and communication between the research workers and the farmers easier. The research programmes operating under the several Commodity Committees were transferred to the reorganised ICAR after the Commodity Committees were abolished, besides the Central institutes which were transferred from the Ministry to ICAR. This has greatly helped to strengthen agricultural research in India but what has contributed most to strengthen agricultural research are two important roles played by ICAR. One is the support for agricultural education and research to the States through Agricultural Universities, and the other is the forging of partnership among different State and Central Institutions in research.

The latter has attracted the attention of many scientists from other countries which have been greatly impressed with this partnership which implements programmes relating to improvement of particular crops or conduct of research in important fields relating to soil and water management, livestock development, etc., through what are now known as All-India Coordinated Projects. These projects represent a unique endeavour towards planning and executing agricultural research on a national basis. The earlier ad-hoc research schemes financed by the ICAR and various Commodity Commitees in the past and operating in an isolated and uncoordinated manner have been replaced by All-India Coordinated Research Projects. In these Projects the chosen problem is visualised for the country as a whole and research centres and sub-centres operating in different parts of the country to meet the needs of areas covered by distinct agroclimatic zones and regions are selected for the coordinated programme irrespective of the State boundaries represented by these stations. To ensure coordination and free exchange of information and experimental material, each Project has been provided with a well-trained and experienced scientist who is appointed as a Coordinator. These projects have developed a multi-disciplinary approach so that research workers in different fields work as a team within an institution and also in the country as a whole. The technical programme of the Project is drawn up in consultation on an all-India basis at the annual or periodical workshops or meetings in which the scientists engaged in the Project participate.

It is largely the results of research done under these projects that the recent breakthrough in crop production in India has taken place. The new dwarf varieties of wheat have helped the country to double its wheat production during the last five years. In the case of rice signs of similar breakthrough are now very manifest and soon the country may claim rice revolution as it has been able to do in the case of wheat. There are coordinated projects in other crops also which have already resulted in the breeding of high-yielding varieties or hybrids. As a matter of fact the first high-yielding hybrids came from the Maize Coordinated Project which was the first one to be conceived, in 1957, and greatly helped the high-yielding varieties programme (HYV) which is now operating in selected areas in most of the States.

It is not sufficient to develop agriculture in a few selected, more favourably placed, areas through programmes like the HYV because such favourable areas represent only a small proportion of the cultivated areas of the country. The major area will continue to depend only upon rainfall and a large portion of it is subject to conditions of moisture stress. Therefore, a programme of dryland agriculture has been initiated during the last two years under which 24 research centres have been started in order to investigate the problems of dryland farming. The results of available knowledge and whatever may come out of research centres are being tested on a pilot basis in as many projects located in the vicinity of the research centres.

Research in crop improvement and in agronomic practices has been emphasising the need of crop rotations and cropping patterns which ensure yield maximisation without harmful effect on soil productivity. In fact the experiments aim at improving crop productivity on a long term basis. These experiments are making use of short-duration varieties in order to suitably replace some of the present-day varieties which have a long duration so that each unit of land can yield the largest produce in a given time. This has led to the concept of multiple cropping which is one of the programmes now being organised in different States.

In helping to bridge the gap between research stations and the farmers, a programme of National Demonstrations initiated in 1965 is likely to play an important role by not only providing field verification of the best results coming out of research programmes but also providing the necessary feed-back from the farmers' fields to the research stations. According to this programme research workers are charged with the responsibility of directly helping selected farmers to successfully use the technology advocated by them for very high and profitable yields. The research workers have given an excellent account of the validity of their research findings through these National Demonstrations which have proved to be of considerable educational value to the farmers. These Demonstrations are being used as a programme of farmers' training so that an ever-increasing number of farmers are able to get not only the know-how but also the motivation which are needed for a rapid spread of new technology.

It can be definitely said that the agricultural programmes in India have resulted in the breaking of the crust of tradition and has started moving the country towards abundance through the efforts of the band of workers who represent agricultural administration, research, education and extension, and many millions of farmers who have shown the needed courage and foresight to adopt new ideas and new technology of agriculture. And it can be legitimately hoped that the commendable achievement of the country of pushng up foodgrains production from 50 million tons in 1950-51 to 108 million tons in twenty years will be bettered in the coming years. This achievement should enable us to face with courage and confidence the present difficult situations which has arisen as a result of very severe drought conditions in the history of this country.

Increasing Sugarcane Production

PROF SHER SINGH
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WE are all aware of the sudden transition from an era of plenty and surplus to that of a tight supply position on the sugar front. Sugarcane cultivation and sugar industry have been subject to wide fluctuations from season to season; so, we have lived in fear of cyclical gluts and scarcities. Consumption of sugar has increased rapidly from 26 lakh tonnes in 1968-69 to 32.6 lakh tonnes in 1969-70 and further to 40.2 lakh tonnes in 1970-71 and on the other hand sugar output has declined rather steeply from 46.2 lakh tonnes in 1969-70 to 37.4 lakh tonnes in 1970-71 and to as low as 31 lakh tonnes in 1971-72. The estimated demand for sugar at the end of the Fourth Plan period is 52 lakh tonnes while that at the end of the Fifth Plan period may touch 60 lakh tonnes taking into account the requirements for exports and buffer stocks. The per capita consumption has been increasing faster than visualised and the projection of 7 kg by 1973-74 has already been achieved in 1971-72 and on this basis a figure of 8 kg per capita in 1973-74 appears to be realistic and besides we have also to feed more mouths in the coming years. This amply points to the gigantic task facing us.

The problems of the sugar industry are well-known. To cite a few, the important ones are the following. Though a number of outstanding varieties have been bred and cropped over large areas, some kind of degeneration causing reduced yields have been noticed in many of these varieties. The practice of growing a single variety in the entire zone of a sugar factory is widespread in sugarcane and that is posing a problem. The crushing season is limited and because of the existing policy of the mills to pay on weight basis, there is no incentive to grow high-sugar content varieties because they yield slightly less in terms of cane although more in terms of sugar per acre.

The contribution that research has made to the improvement of the sugarcane industry has been significant. We have two major Sugarcane Research institutes at Coimbatore and Lucknow. The former has been mainly responsible for breeding new varieties while the Lucknow institute tackled other aspects. The major improvement was on the varietal front and the yield of North Indian Canes for example, have gone up from 10 tonnes/acre to 15 to 20 tonnes. A stability in performance has been achieved. The improved varieties such as CO. 419 in the South, CO. 312, CO. 1148 and the B.O. varieties in the North now occupy vast areas. Another aspect which has considerably helped in increasing the yield of sugarcane is the appreciation on the part of farmers of the advantage of high fertilizer doses. The use of resistant varieties such as CO. 1148, CO. L. 9, B.O. 17, etc. for resistant to red rot and CO. 52-7 and CO. 449 with respect to smut has also led to appreciable yield increases. The use of aerial spraying of Malathion for control of the dreaded *Pyrilla* has helped to prevent epidemics.

Research on crops is a continuing process and research has to solve problems as they arise. The fact that we have today a difficult situation is ample justification for more intensive research and not only that but the adoption of research findings which are already available, is equally important. The I.C.A.R. has also been operating an All India Coordinated Project on Sugarcane with the object of increasing production through intensive research.

The use of early maturing varieties and ratoons for crushing is a well-known practice for achieving higher recoveries of sugar. But in practical terms, this is not done due to the existing cane purchase policy. Twenty-five early varieties have been placed on the approved list in various sugarcane growing states. CO. 1336 for instance is useful for early crushing, having good sucrose and yield characters but also maintains its juice quality till late in the season. It is also moderately resistant to red rot and smut. There are some newer promising varieties also like CO. 6804, 6806, 6807 and 62174. CO. 6806 for instance has the capacity to yield 12.88 tonnes sugar/ha (12 months) and is resistant to red rot and smut. Several late varieties are also available to improve the recovery of the factory in the later part of the season. These include CO. 62175, B.O. 29, CO. 1148, CO. 740, CO. 62399, etc. An ideal system would be to start crushing ratoons, which mature earliest than the early canes, the mid-late and the late varieties in sequence to increase the recovery.

In CO. 997, a variety widely grown in Andhra Pradesh, a mutant has been obtained which is resistant to red rot and this has considerable potential both in Andhra Pradesh and in the Northern belt where there is a dearth of high sugar varieties which are red rot resistant and early.

Fertilizers are the key to bringing out the full potential of the improved varieties. It has been shown that late application and excessive doses, particularly of nitrogen, affect the juice sucrose adversely. It is necessary that the correct method and doses are adopted.

Proper and full utilisation of the area is important more so in respect of the small holdings. Inter-cropping is one way of achieving this and this area of research is being intensively explored. A wheat-sugarcane inter-cropping has been found to give nearly Rs 400 as extra income when wheat is sown in between sugarcane in 2 or 4 rows. In the northern belt the use of wheat in rotation with early harvested sugarcane looks quite promising.

The presence of weeds in sugarcane fields has always been a sore problem. Chemical weed control has come to the forefront in modern agriculture, as an easy and economical method. Their use has become all the more important in view of the considerable increase in the wages of labour. Research on this problem shows that some chemicals like Simazine (at 3.75 kg/ha in 700 to 900 litres of water) when applied 2 to 3 days after planting sugarcane is safe and efficient.

Ratooning of sugarcane is a general practice and became more widespread ever since the introduction of the Coimbatore canes and now as much as 30 to 40% of the crop area is under ratoons. But the practice has not received as much attention as the main crop and the ratoon crops are not provided with proper culture, manurial, irrigational and plant protection inputs. This has resulted in low yields from ratoon crops and they are often infested by a number of pests and diseases which serve as a source of infection, that is pests and diseases are carried from such fields.

Ratoons give a lower yield with a better juice quality, particularly in the early part of the crushing season as compared to the plant cane. CO. 419 is very well-suited to ratooning. It will be useful if one ratoon crop is taken to reduce the cost of cane cultivation.

Virus Diseases

Research investigations carried out on degeneration or reduction in yields met with in improved varieties have established beyond doubt that this is brought about due to the gradual accumulation in the seed canes of two virus diseases called ratoon stunting and grassy shoot, the former having no visible symptoms. The virus diseases are passed on through the seed pieces. The ratoon stunting disease not only reduces the yield but also restricts the practice of ratooning which is a profitable practice. Other diseases also occur. Excellent varieties like CO. 312, CO. 527 etc. have been given up due to increasing losses in these varieties. In the North, the red rot disease has been causing similar havoc. Smut is another serious disease. While the smut, mosaic and red rot can be effectively reduced by careful selection of 'seed', in the case of ratoon stunting and grassy shoot, it is necessary to use heat therapy to eliminate the viruses from the seed pieces. Thus, a programme of heat therapy coupled with a sound seed selection programme for one to two generations would supply good disease free seed material. Experiments conducted at the Indian Institute of Sugarcane at Lucknow show that the varieties that have degenerated due to virus diseases can be revived by heating the seed canes in especially designed units and the additional increase in yield may be 30 to 40%. In this process, the seed infection by the lethal red rot fungus is also eliminated. The average farmer has not been able to derive the benefits largely because the whole process of treatment, selection and certification is extremely technical. It is necessary that a programme of production of certified disease free seed caters to this need and for this purpose, the I.C.A.R. has formulated a Co-ordinated Foundation Seed Programme on All India basis. This programme when fully implemented will lead to a significant increase in production and the farmers will have so much less worry with the disease problem and would have to spend much less on disease control.

Chlorosis is another disease on planted and ratoon crops. It has been found that spray applications of ferrous sulphate (0.25 to 0.5%) at weekly intervals help the plants to recover.

Insect pests are reported to cause a loss of Rs 50 crores/annum to the sugarcane crop. The borers are the most important pests. Control measures have been evolved for most of these pests and strict adoption of the practices by all the growers would lead to increased yields. It is very necessary that insect pockets are not left unattended as these will serve as sources for the pests to reoccur.

The production of 'gur' is an important industry. Not all varieties are suitable for this purpose but varieties such as CO. 419, CO. 312, CO. 313 CO. 1336 etc. have been found to be suitable. A new process namely, the vacuum process extracts juice to the extent of 80 to 85% and 'gur' recovery will be 15—16% as against 10—11% in the conventional method. Higher production of gur during gluts and its refinement into sugar later on by sugar factories in the next season or in the off season will lead to better all round economy.

There are great possibilities and immense potentialities for the future and we may reasonably hope that with the aid of research and the active cooperation of the farmers a new era of plenty is bound to come.

AGRICULTURE CANNOT WAIT

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BEFORE 1947, the quantum of effort generated in agricultural research and education was microscopic in relation to the magnitude and diversity of the problems awaiting solution although as early as in 1928 the Royal Commission on Agriculture had laid considerable stress on harnessing science to develop and spread new technologies for the arid, semi-arid and irrigated areas. The Indian Council of Agricultural Research established in 1929 was itself an outcome of a recommendation of the Royal Commission. Nevertheless, the Council had neither the authority nor the resources to effectively stimulate and coordinate agricultural research and education in the entire country. Agricultural education enjoyed low social status because of the widespread prevalence of the view that agriculture was a profession needing only brawn and not brain. That is why Mahatma Gandhi attached so much importance to ending the divorce between intellect and labour in rural areas. As a result of the poor social status attached to agriculture as well as the poor returns and high instability of income observed in farming, only students who could not get admission in other professional courses like medicine and engineering as well as in honours courses in science and arts usually tended to gravitate towards agricultural colleges. The manpower of agricultural departments was hence generally inadequate both qualitatively and quantitatively for facing successfully the numerous complex problems posed by the wide range of agro-climatic and socio-ecological conditions met with in the country.

What work was done prior to Independence in our research laboratories seldom found widespread adoption in the field, either because arrangements were not made for the production and distribution of inputs like seeds, pesticides and fertilizers and/or because of very poor extension services. The extension worker by and large had very little to extend either by way of knowledge or of inputs and therefore became an object of ridicule and condemnation. The research workers were also condemned frequently as 'ivory tower' scientists with little concern for the welfare of the farmer. Even as recently as ten years ago, the view that what the country needed was not more research but only extension of the known results of research was widely held. Thus, when India became independent we had inherited an agricultural research and education system which had neither the social prestige nor the self-confidence essential for helping to transform the agrarian economy. It is in this context that the call given by the late Shri Jawaharlal Nehru that "agriculture cannot wait" became so significant in ushering in a new perspective for agricultural growth.

Viable and Productive Agricultural Economy

Just before we became indepencent we had witnessed a great human tragedy in the form of the Bengal Famine. Famines had been a recurrent theme in our national history for a long time and it is, therefore, not surprising that Shri Jawaharlal Nehru announced that one of the first tasks of independent India would be the development of a viable and productive agricultural economy leading to self-sufficiency in our food requirements. Several steps were taken to give effect to this resolve and during the period 1947 to 1960 much progress was seen in infra-structure development through the community development and other programmes. The infra-structure development made it possible for scientific results to strike roots and bear fruit quickly when they started becoming available in more relevant forms during the last twelve years. An index of governmental interest in agricultural research and education can be found from figures concerning the funds made available to the Indian Council of Agricultural Research for work in these fields (Figures 1 and 2). Today, we have 23 well-equipped and well-staffed research institutions all over the country directly supported by ICAR. In addition, there are eight Soil Conservation Research Centres. We have 19 Agricultural Universities with nearly all States having one Agricultural University each and Maharashtra having four such Universities. Through the All-India Coordinated Research Projects of ICAR an excellent machinery has been created for integrated research on all problems of national importance in agriculture, animal husbandry and fisheries. There are 69 such projects currently under operation and a unique feature of these projects is that they provide a mechanism for bringing together scientists working in different disciplines and under different administrative hierarchies into a common working family. Above all, the most important strength of our agricultural research system lies in the national grid of cooperative testing programmes and the rigour of the screening programmes of every experimental finding before it is passed on to the farmer. Since this aspect of our agricultural research system is not so widely known as it deserves to be, I would like to give a brief outline of the procedures followed.

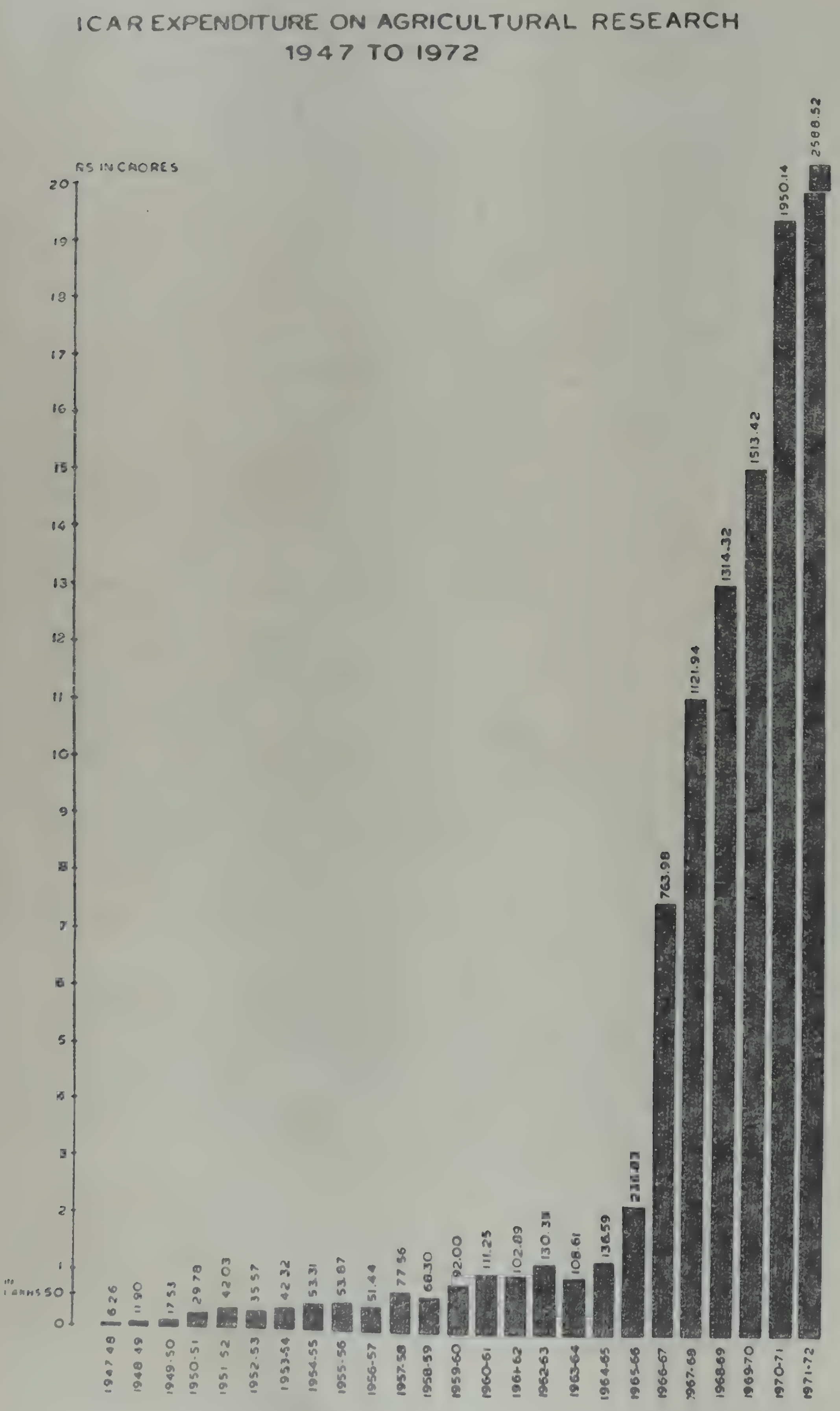

Fig: 1

Step 1—After years of research, scientists develop new crop varieties/agronomic techniques.

Step 2—New strain/practice is tested all over the country in coordinated trials for about three years or three seasons by numerous investigators belonging to different research institutions and Agricultural Universities. *Step* 3—New strain and the appropriate package of practices tested under the All-India Coordinated Agronomic Experiments Scheme (Step 2 and 3 may take place concurrently).

Step 4—Data from the coordinated trials are statistically analysed and discussed in annual workshops and recommendations made on the basis of such discussions.

Step 5—Significant results tested/demonstrated in farmers' fields under the National Demonstrations programme and more recently also under the Minikit Programme.

Step 6—The Central Variety Release Committee of the Union Ministry of Agriculture or the Variety Release Committees of Agricultural Universities/State Governments consider all the available

ICAR GRANTS FOR AGRICULTURAL EDUCATION 1961–1973

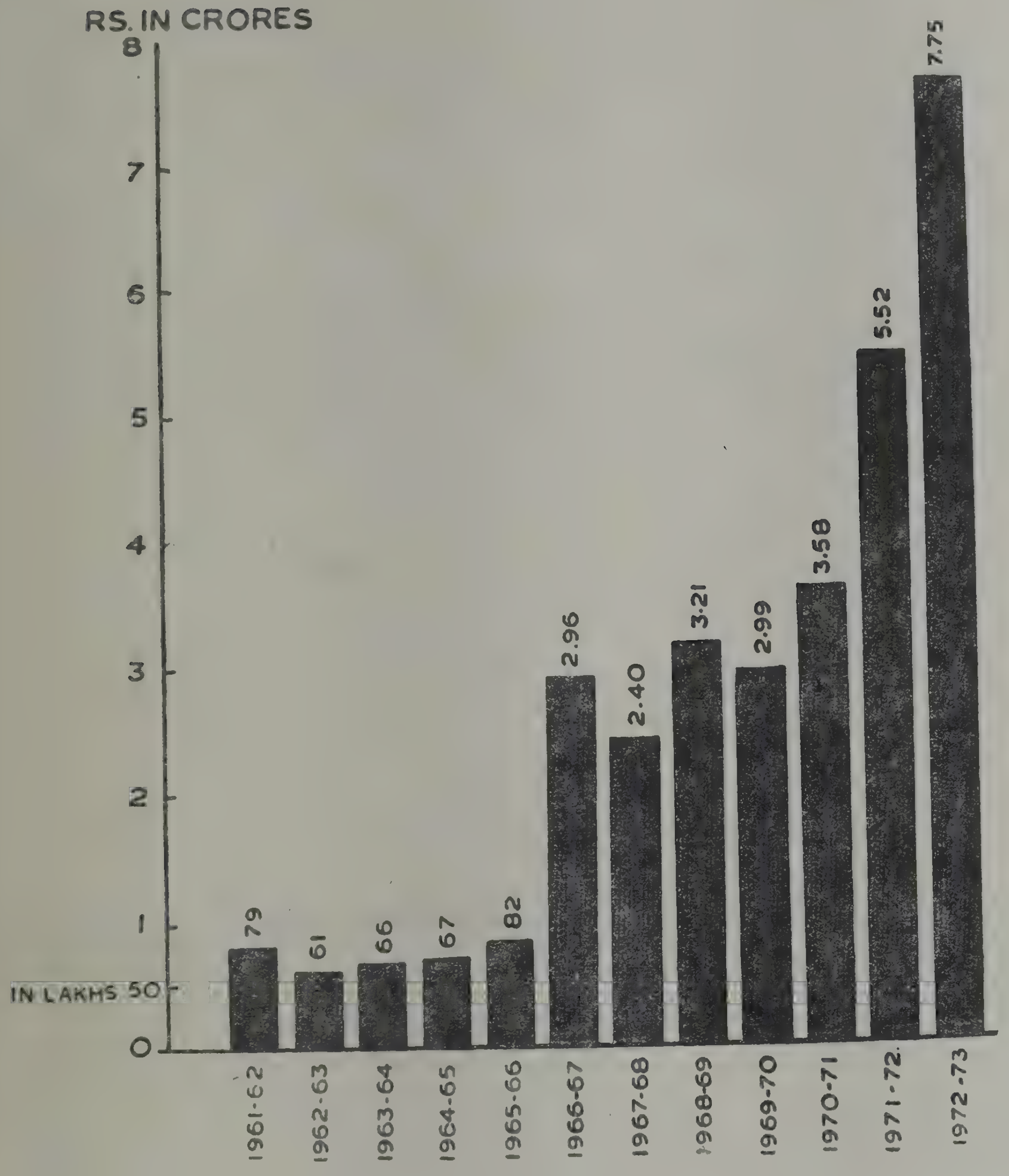

Fig. 2

data (yield, fertilizer response, disease and pest reactions, quality characteristics etc.) and make recommendations about the suitability of a new strain for release for cultivation by farmers. These Committees also specify the area of adaptation of the new varieties.

In crops like rice which are grown from sea level up to nearly 3000 metres altitude considerable variations naturally exist with reference to adaptation for different agro-climatic conditions and consumer preferences and hence an intensive programme of minikit demonstrations-cum-trials have been initiated. The number of such demonstrations put up in farmers' fields with different new varieties during 1972 is given in Table I. No wonder that any variety or technique which has successfully passed through so many sieves becomes a success in the field. This does not mean that a new variety may not succumb suddenly to a new disease or a new strain of an already prevalent pathogem, e.g., this is what happened with the famous miracle rice varieties in the Philippines when they were badly damaged by the Tungro virus outbreak during 1971. This is only a warning that there is no room for complacency and no time to relax as far as agricultural research, education and extension efforts are concerned.

Agriculture is becoming an increasingly sophisticated occupation. With the growing awareness of the ecological dangers arising from the inappropriate and unscientific use of agricultural inputs like pesticides, fertilizer and water, steps are under way to develop techniques like integrated pest control, watershed management etc., which will ensure that productivity is continuously enhanced without any danger to the long term production potential of the soil.

CONTINUED ON PAGE 25

TABLE I. MINIKITS BY RICE VARIETIES

Variety	*No. States*	*Farmers*
IET 1991	17	20,360
IET 1039	12	9,960
IR579-48	4	6,050
Gallmidge Resistant Varieties	10	4,650
IR 20	4	5,600
Vijaya	4	4,150
CR 44-35	6	3,810
14466	1	3,300
New Sabarmati	4	2,950
Basmati Dwarfs	5	2,475
Bala	2	2,000
Pankaj	2	1,700
Tungro Virus Resistant Varieties	5	500
Cauvery	1	500
CR 36-148	1	500
Malinja	1	500
CR 44-1	1	310

TWENTY-FIVE YEARS OF RESEARCH IN SOIL, FERTILIZER AND WATER MANAGEMENT IN INDIA

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SOIL is the backbone of an agricultural country. Neglect of soil has ruined nations. India has not only diversity of climate but also a large variety of soils, differing in colour, texture, physico chemical properties and productivity.

Before independence of the country soil research had not received adequate attention as a distinct discipline separate from agricultural chemistry. However, with the introduction of canal irrigation, the necessity of basic research and survey of soils of many States were started but it had numerous shortcomings and did not come up to the level of standard soil survey. There was no institute exclusively for soil research though fragmentary work was done everywhere.

A new concept of soil fertility

In 1947 after independence and unnatural partition of the Indian sub-continent, a great imbalance in food production was experienced and research and demonstration programme for the use of fertilizer was started. Some fertilizer experiments on cultivators' fields were started which brought out a startling revelation that the fertilizer responses obtained on experimental stations did not reflect the true picture of soil fertility of cultivators' fields.

Differential response to the application of phosphatic fertilizers

Unlike the traditional notion which was based on the work of experimental stations, it came to be realised that soils of the farmers fields are deficient not only in N but in phosphorus and potash as well. This led to the development of a new concept of soil fertility evaluation by actual performance tests on cultivators' fields. This concept has been adopted by FAO for Soil Fertility and Fertilizers work in all the developing countries.

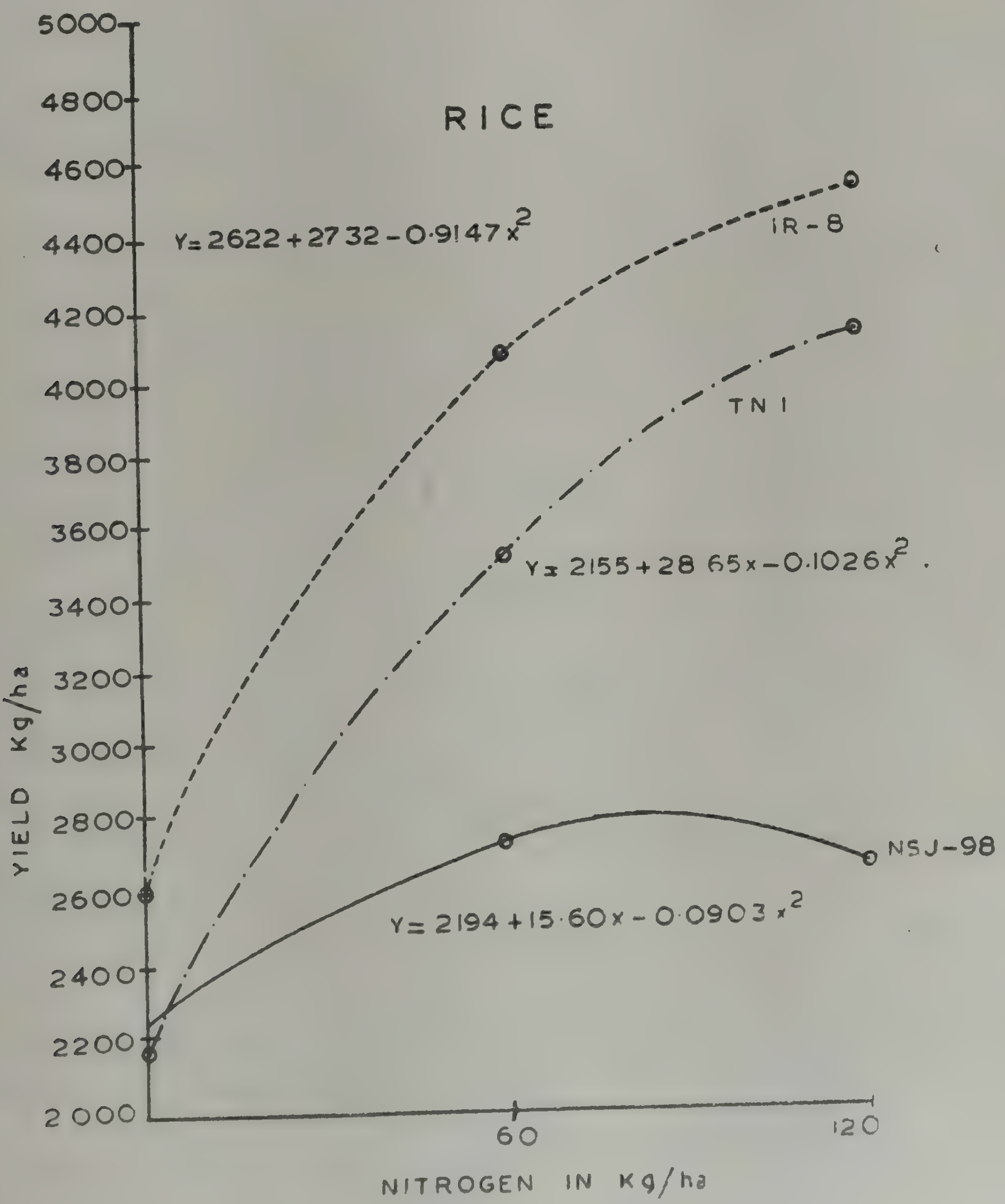
The necessity of research on soil testing became very evident and under the U.S. Assistance Programme, a net work of 24 soil testing laboratories was set up. The results of soil analysis began to reveal how widespread was the deficiency of P and K.

Another concept of complex agronomic experiments for location specific researches on soil fertility problems of different soils was developed, which led to the formulation of a coordinated scheme of model agronomic experiments.

Fertilizer responses are higher with the high-yielding varieties

The fertilizer responses to N, NP and NPK became more spectacular with the introduction of high-yielding varieties which are many times more responsive to fertilizers than the tall varieties of wheat, rice, sorghum, bajra and maize (Fig. 1). It hae also been observed that these varieties not only give two to three times higher responses per unit nutrient at higher level of application of fertilizer but also give better performance even at native fertility of the soil. If the miracale seeds are the catalysts of green revolution, the fertilizer and soil fertility management is the thrust behind the revolution. The field and laboratory experiments revealed that the responses invariably varied as NPK>NP>N (Table I, Fig. 2) and the responses also varied according to the magnitude of nutrient deficiency (Fig. 3.) Moreover, the net returns also

Fig.1. Response of high-yielding varieties of crops to nitrogen—Rice. The response of the various crops to nitrogen is given in following figures marked 'Fig.1 contd.'



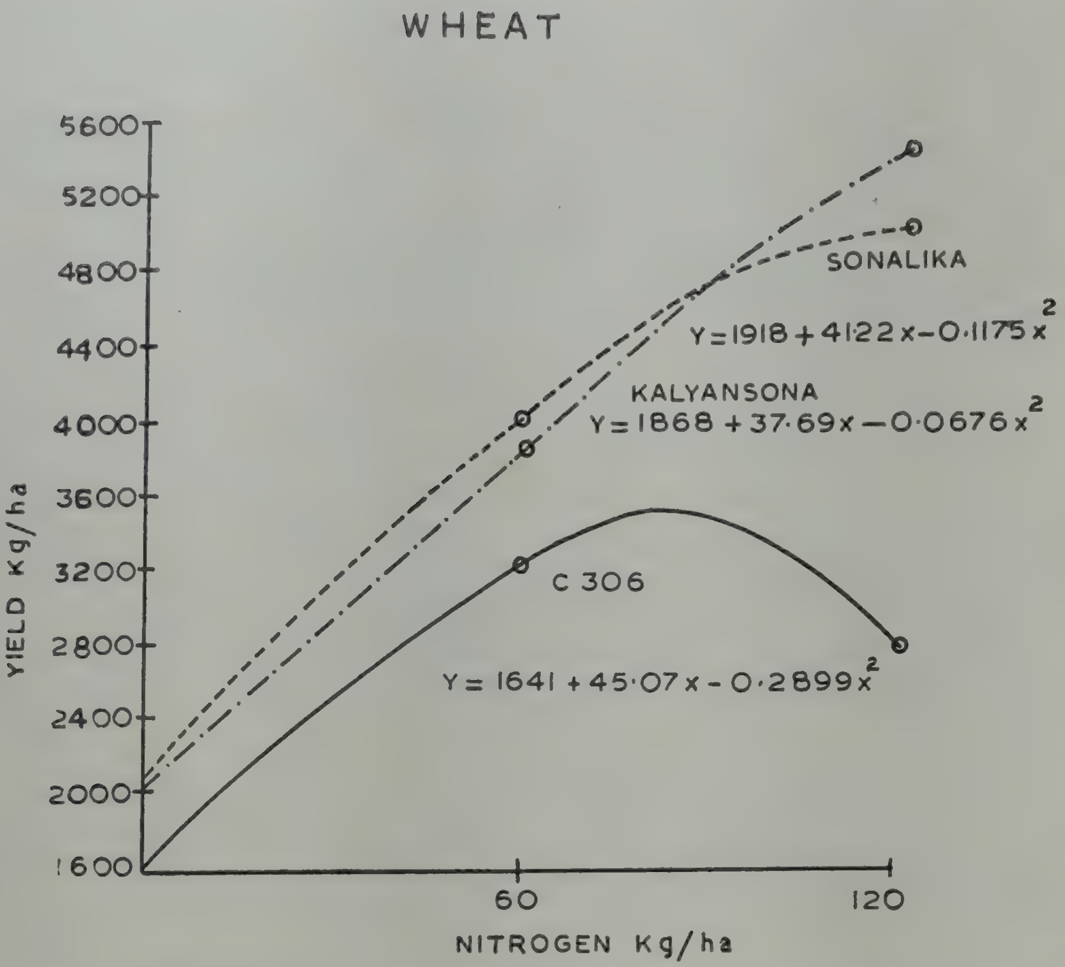


Fig.1. cond.

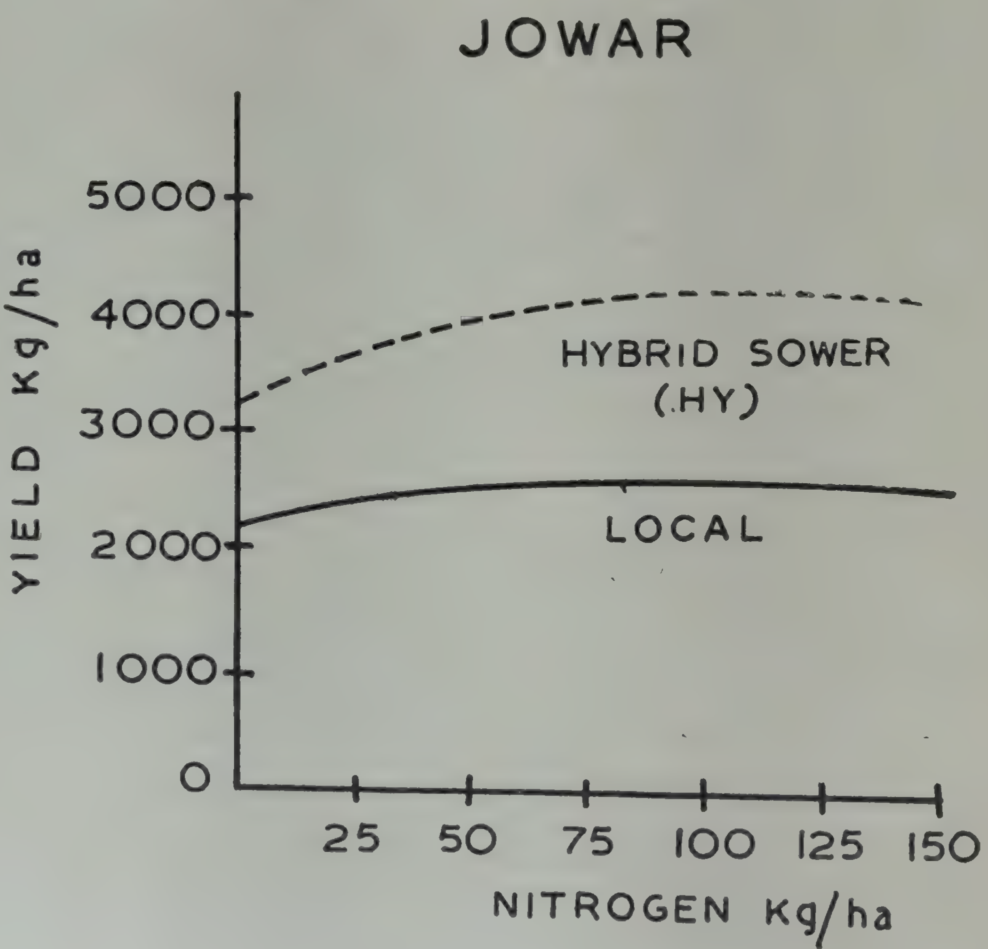
improved with the balanced use of fertiliser as is evident from Table II.

The phosphate fixation studies revealed that the phosphate responses could be related to the nature of the soil and phosphate fixation capacity. The laterite, Red and Black soils were the most deficient in phosphate and needed adequate fertilization with phosphates. In fact in many soils responses to N were poor without the application of phosphate. The correlation of soil phosphorus extractable with Olson's method using sodium bicorbonate solution was excellent. Thus soil testing formed the basis of fertilizer application in many States.

Micro-nutrient deficiency widespread

The soil fertility research in some of the States like Punjab, Maharashtra, Gujarat also developed studies on micro-nutrient deficiency problems of soils. Under the I.C.A.R. scheme, deficiency of micro-nutrients like zinc and iron was discovered in the Punjab; mangnese and molybedenum deficiency in Maharashtra and Gujarat and boron deficiency in Bihar. This ultimately led to the development of a coordinated scheme of research on micro-nutrients. In the meantime zinc deficiency in paddy soils of Tarai region of U.P. was also identified. The Indian research on micro-nutrients is a pioneering work which has been recognised even by highy developed countries like the U.S.A. The researches on micro-nutrients have shown that in many districts significantly large percentage of soil samples are deficient in zinc (Table III). It has also been observed that yield increases of the order of 10-30 per-cent and in cases of the acute deficiency even as high as 80-90 per-cent increase have been observed, as is evident from Table-IV. The micro-nutrient deficiency is being accentuated by the high-yielding varieties, intensive cropping and large use of

Fig.1. contd.



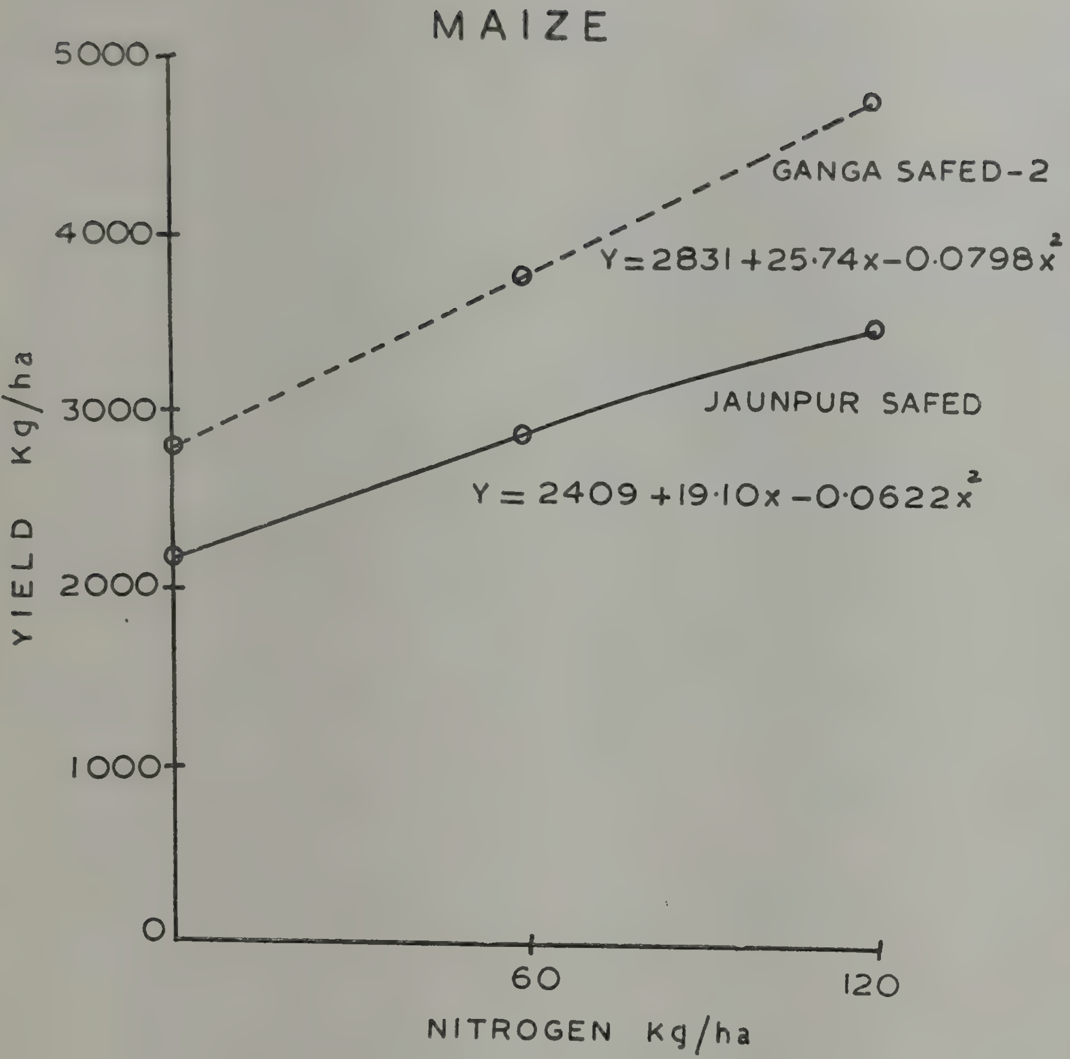


Fig.1. contd.

Secondary nutrient deficiency is appearing

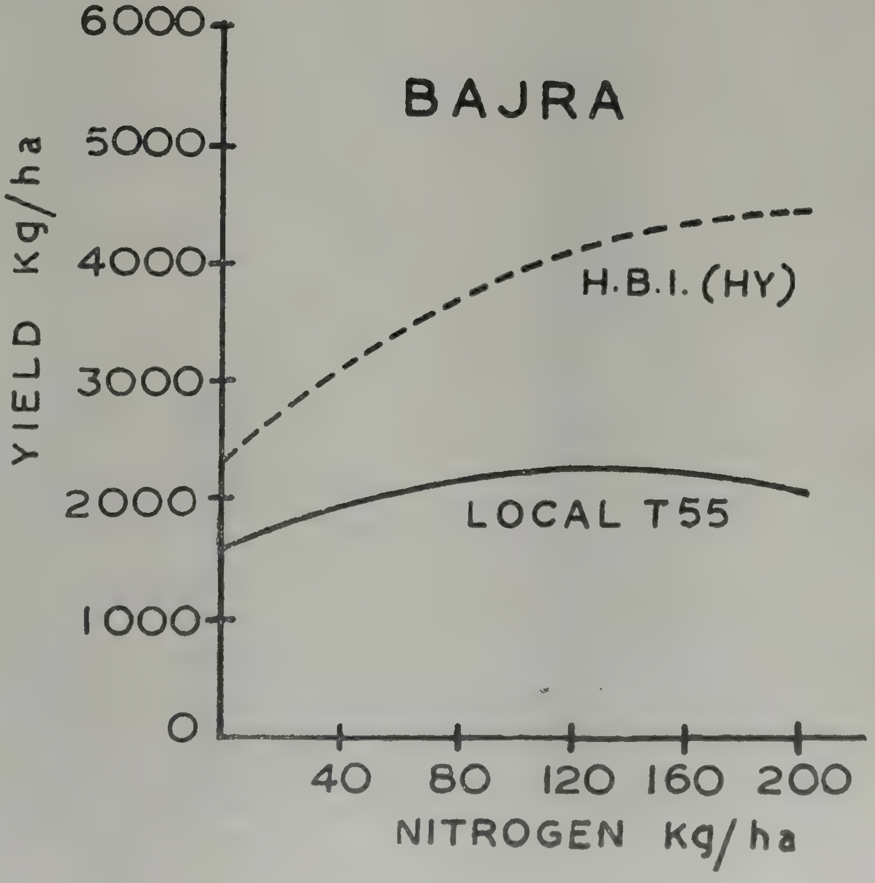
Studies conducted in Punjab, Madhya Pradesh, Delhi and Haryana have shown deficiency in sulphur becoming critical for legumes like groundnut, berseem and alfalfa. The deficiency of Ca and Mg have been reported from acid soils of Chota Nagpur (Bihar). Madhya Pradesh, Himachal Pradesh, Mysore, etc.

It is becoming evident that we can't exploit these soils indefinitely as the limitation of multiple nutrient deficiency begin to affect the yields.

Soil test crop correlations for targetted yields

Modern agricultural technology is input intensive which are costly thus the cost benefit considerations enter into the problem of fertilizer application. A farmer is interested not only in increasing yields but also in maximising his returns, thus establishment of relationship between soil tests and crop responses to fertilizer and inadequacy of farmyard manure. It has also been established that there are wide differences in susceptibility of various varieties to a particular micro-nutrient. (Table V). Thus a new philosophy of rational use of varieties and fertilizer, according to soil tests has been developed. The effect of fertilizer such as phosphates on availability of zinc has received considerable attention and a sound philosophy for the application of major and micro-nutrient application is being developed. In some areas of Punjab, Haryana and Andhra Pradesh, it has been discovered that the high-yielding varieties fail to give high yields unless 20-25 kg, zinc sulphate is applied in addition to NPK and other practices. The work on this important aspect is being followed most vigorously under the coordinated micro-nutrient scheme of the I.C.A.R.

Fig.1. contd.



fertilizers becomes most important. The researches on soil test crop response conditions have developed mathematical equations for such relationship for a few crops and soils (Table VI). The work is being intensified to meet needs of the country for this type of knowledge.

Why and how much organic matter

The time honoured controversy why and how much organic matter and fertilizer has a number of facets. The researches in the last 25 years have shown very clearly that the rates at which organic manures are added to the soil are hardly adequate to compensate for the loss of organic matter due to rapid oxidation in Indian soils. The climate does not permit building up organic matter content to a high level. Therefore, the practical approach is to maintain the turn over of the organic matter. The investigations on green manuring have shown that where the economic consideration rides high, it can hardly compensate for the loss of a crop but under special situations such as reclamation of saline alkali soils and improving soil structure it has a place. Likewise, in case of organic manures, it is abundantly clear that as a source of readily available nutrients they can hardly compete with the fertilizers, but as adjuncts with fertilizers, particularly for improving soil structure they are very useful provided the amount added is fairly high.

The studies on rate of oxidation of various organic matters show that very rapid humification takes place but there are indications that organic matter is a good source of detoxifying the soil pollutants like pesticides. Thus in future researches along this line will be essential.

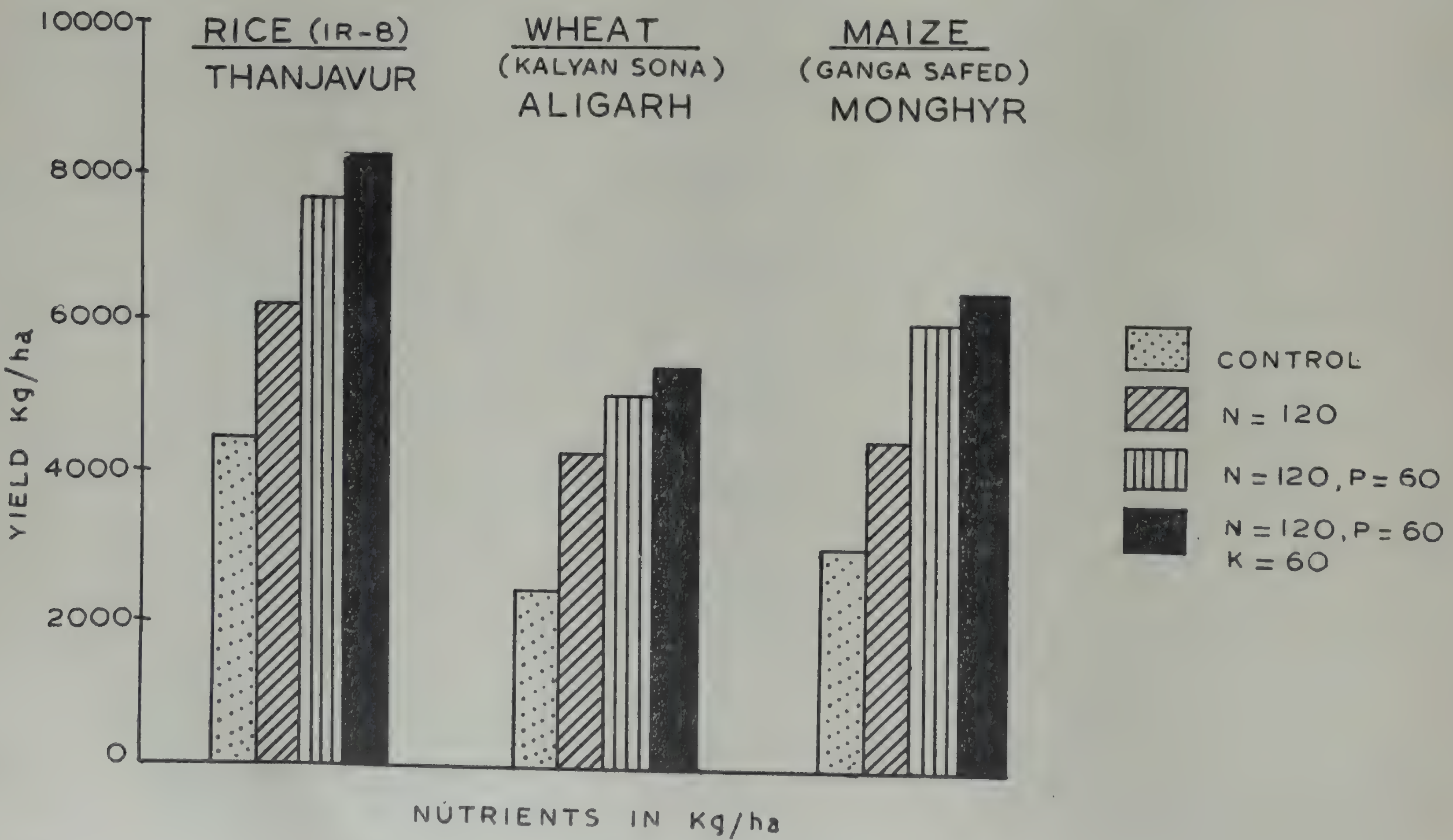
Residual effect of fertilizers

How much residual effect of fertilizer applied to previous crop will benefit the succeeding crop is an important question for every farmer. The studies reveal that Indian soils are so deficient in most of the nutrients that for obtaining best results one has to count on the direct application of fertilizer. The residual effect has only small significance for practical purposes. However, where the phosphate and organic manure application is continued over longer number of years, the build up of residual effect is measurable. Phosphates, particularly have more residual effect than any other fertilizers; but in heavily fertilized crops like potato and sugarcane, the subsequent cereal or forage crops benefit from it considerably.

Method of application of fertilizers

A large number of field experiments have revealed that in case of phosphates drilling of fertilizers increases the availability of the fertilisers applied to the crop but in case of paddy broadcast gives best result. In case of nitrogen drilling for paddy and band placement for other cereal crops gives good yields. Split application of fertilizer is invariably the

Fig. 2. Response of high yielding dwarf varieties/hybrids of cereals to combined application of nitrogen, phosphorous and potassium on cultivators' fields.



best but the economics has to be carefully considered. Some interesting results have been reported regarding split application of potash and even phosphate for paddy. The results are still inconclusive.

There are situations where foliar application of urea has given good results but the bulk of the experimental evidence shows that half soil and half foliar spray or whole dose applied to soil are most efficient and economical. Many problems of soil fertility and fertilizer use efficiency have been studied using radio active isotopes. In fact, many agricultural research laboratories are now equipped to use tracer techniques for investigation of very intricate problems.

Soil management, reclamation and improvement

Numerous studies have been made by the individual scientist or a team of scientists under coordinated schemes to develop practices for efficient soil management, reclamation and improvement.

During the last 25 years, the researches on reclamation of saline alkali soils took a new turn and as against the traditional approach some new vistas were opened. The scientists of the Punjab Agricultural University under ICAR scheme on reclamation of saline alkali soils established that these soils are very deficient in plant nutrients hence for their amelioration application of fertilizers and manures is absolutely essential. Secondly, the process of reclamation should consist of accelerating the biological activity in the surface soil by application of manure, fertilizers and green manures accompanied with gypsum or other soil amendments, using Dhancha Paddy-wheat/Barley/Berseem/Sugarbeet rotations. Recent studies by the Central Soil Salinity Research Institute, Karnal, have shown that for saline alkali soils with high exchangeable sodium, application of gypsum at one-fourth of the required extent by soil analysis is essential, provided proper soil management is done by liberal use of fertilizers and manures and zinc sulphate in the rotation. (Table VII). In 2 years the soil was brought to the normal production. This opens up a new chapter in the reclamation of saline alkali soils in India.

Irrigation water

Hitherto, the soil scientists were content with the chemical analysis of the water sample for the dissolved salts and giving pronouncement about the quality of water based on this analysis alone. A new concept has been developed over the last two decades about the criterion of the quality of water. The quality

Fig. 3. Response of wheat to phosphorous and potassium in relation to fertility status.

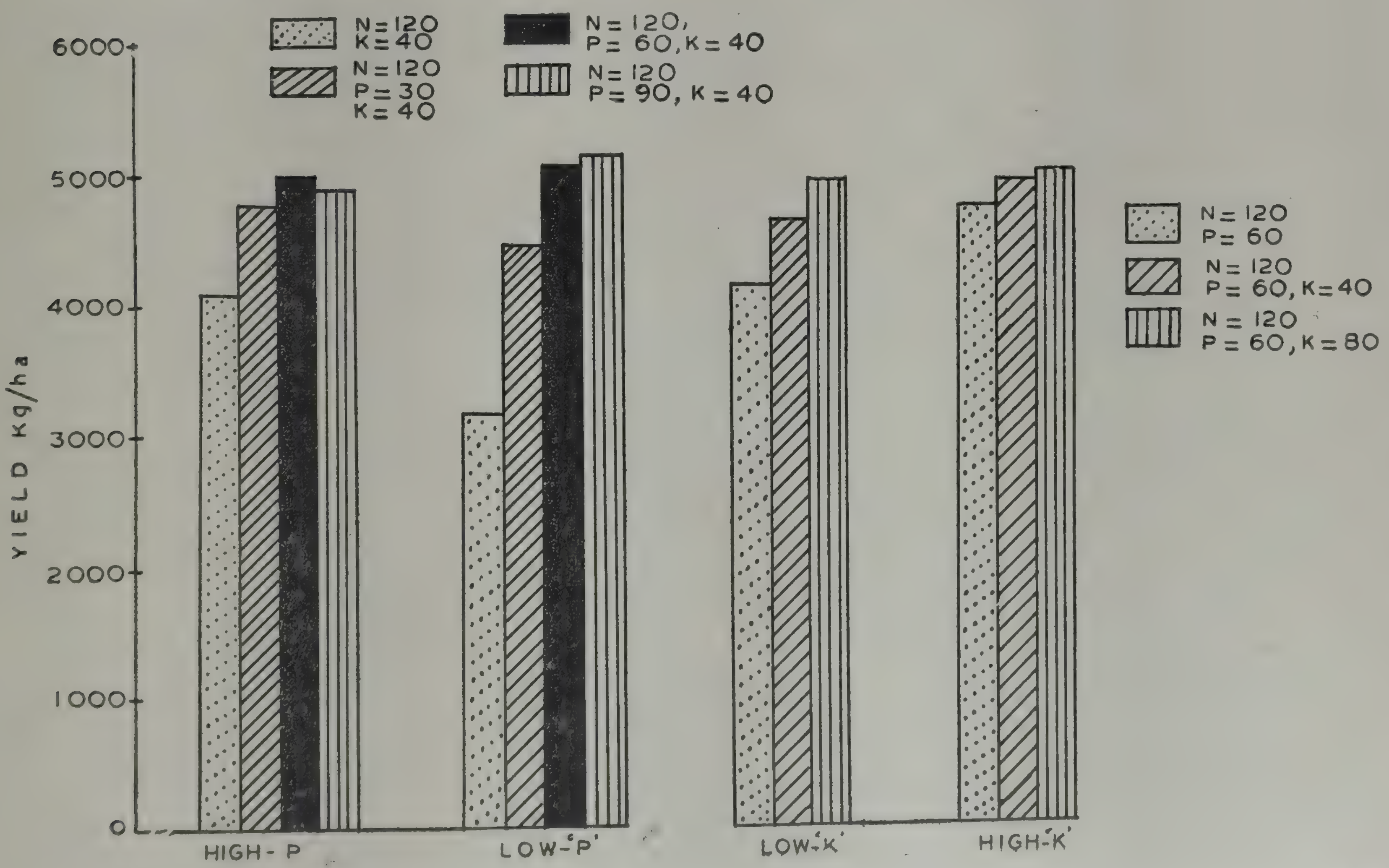


TABLE I. RESPONSE OF HIGH-YIELDING VARIETIES OF RICE AND WHEAT (KG/HA) TO NITROGEN AND PHOSPHORUS

	District	*Varieties*	*No. of trials*	*Average yield of untreated plots*	*Response to*			
					120 kg/ha N	*120 kg N +60 kg* P_2O_5	*N 120, P 60, K 30*	*N 120, P 60 K 60*
				RICE				
1.	Shahabad	IR-8	117	1962	1494	2069	2179	2487
2.	Karnal	IR-8	67	1795	1510	2205	2051	2265
3.	Cuttack	IR-8	23	2052	1119	1580	298	1640
4.	Varanasi	IR-8	79	2027	1106	1440	—	1640
5.	Raipur	IR-8	119	2882	1137	1912	1752	2221
				WHEAT				
1.	Ludhiana	C. 306	59	1932	635	1556	1316	1383
2.	Hoshingabad	Hy-65	124	1312	1148	1977	1740	2070
3.	Karnal	C. 306	57	2177	1068	2226	1355	1496
4.	Kanpur	K-68	85	1814	917	1282	1405	1516
5.	Shahbad	NP-884	164	1311	1185	1631	1538	1844

Source: Data of the all India Co-ordinated Agronomic Trial Scheme (Unpublished).

is determined by the interaction of a triangle of water, soil and a crop. Thus an irrigation water can be used successfully for a certain soil and a crop without any deleterious effect. Studies are under way to deviop techniques of using saline water for agriculture.

Dry farming

The widening gap between the farmers of the irrigated areas and the dry farming areas and instability of agriculture due to unreliability of rains and the fact that three-fourth of the cropped area is still unirrigated, the necessity of intensified research on dry land agriculture was felt. In the first two decades, the subject hardly received any attention. In the Fourth Five-Year Plan it has become one of the most important programmes. Under the coordinated scheme of research wherein teams of scientists have started working on the important problem. The indications are that introduction of some new crops like sunflower in black soil region is very promising (Table VIII). The use of high-yielding varieties of sorghum and bajra with application of phosphates and nitrogen in many arid areas with proper soil and crop management system gives significantly higher yields. Studies on water harvesting, soil and moisture conservation and use of meteorological data for crop management are receiving attention. It is felt that it will take long time to develop suitable technology for these arid lands but whatever techniques are known, can be transmitted to the farming community. Pilot projects for the purpose have been taken up in 24 districts.

Soil conservation

Before 1954 there were no facilities for research and training in soil conservation. Nine soil conservation research and training and demonstrations centres were set up in different regions. The first priority were given to the training of adequate staff for manning various positions of soil conservation programmes. More than 1,000 officers have so far been trained by the Soil Conservation Centre, Dehra Dun alone. Despite the inadequate facilities for research, all these centres have accumulated very useful information about soil erosion and developed structures for controlling it. The studies on loss of nutrients from a soil on the 8 percent slope at Dehra Dun showed that the annual loss of nitrogen available Phosphorus and vailable potash was 228.1, 70.5, 28.8 kg/ha. Keeping the land under grass reduced the loss to a negligible extent.

Napier hybrid grass, hybrid maize and cowpeas were most successful on the gravely red soil at Hyderabad. At Bellary, advancing the date of sowing of hybrid sorghum by one month increased the yield of the crop significantly over the

TABLE II. NET RETURN DUE TO FERTILIZER USE IN WHEAT—KALYAN SONA ON CULTIVATORS' FIELDS

(Percentage of cases falling in different categories)

	Ludhiana district (141)			*Hoshangabad (249)*			*Karnal (124)*		
	Alluvial soil			*Black soil*			*Alluvial soil*		
Net return/ha	*N*	*NP*	*NPK*	*N*	*NP*	*NPK*	*N*	*NP*	*NPK*
		%			%			%	
Less than zero	19	1	3	4	2	1	2	—	—
1–500 rupees	33	9	8	27	4	4	17	7	6
501–1000 rupees	32	18	27	36	13	11	34	19	25
Over 1000 rupees	16	72	62	33	81	84	47	74	69

Source : Data on All India Co-ordinated Agronomic Trials Scheme (Unpublished).

TABLE III. MICRO-NUTRIENT DEFICIENCY IN VARIOUS STATES

(Percentage of soil samples)

State	*Districts*	*Percentage*
Punjab	Ludhiana	40
	Hoshiarpur	20
Haryana	Gurgaon	68
	Jind	67
Uttar Pradesh	Basti	45
	Gorakhpur	71
	Deoria	88
Madhya Pradesh	Demoh	12
	Jabalpur	2
	Raison	37
	Saugar	25
	Tikamgarh	17
Bihar	Poornea	16
Andhra Pradesh	Nizamabad	61—85
	Karim Nagar	70—87
	Chittoor	52—66
	W. Godavari	67
Tamil Nadu	North Arcot	16
	South Arcot	17
	Nilgiris	9
Gujarat	Surat	21
	Banaskantha	23
	Bulsar	16
	Daman, Dadra	4

Source: I.C.A.R. annual report (1970–71)

TABLE IV. EFFECT OF ZINC ON THE GRAIN YIELD OF MAIZE

Grain yield q/ha

Location	*Control (NPK)*	*Soil application (5 ppm zinc)*
Ludhiana	49.56	52.52
Anand	36.75	39.06
Jabalpur	42.77	37.02
Delhi	50.20	62.50
Ambala	47.92	68.52
Hissar	38.55	53.83

Source: All India Co-ordinated Agronomic Experiments Scheme (Unpublished).

TABLE V. RELATIVE SUSCEPTIBILITY OF ZINC

Crop	*Relative susceptibility of varieties to zinc deficiency*		
	Controlled	*Culture*	*Studies*
	High	*Medium*	*Low*
Wheat	Hira, HD-1941	K-68	WG-377
	HD-1944	K-816	WL-212
	Safed Lerma	Lal Bahadur	UP-301
	Chhoti Lerma	Sonalika (S-308)	
	C. 306	Sonora-64	
	Kalyan Sona	Sharbati Sonora	
	PV-18	WG-357	
Rice	Pusa-2-21	IR-8	Sabarmati
	Jamuna	Padma	IET-355
	Jaya	Vijay	N-205
		Cavery	Ratna
		TN-1	Annapurna
		Karuna	Kanchi
		Hamsa	
		Bala	
		IR-20	
		T-9	

Source: I.C.A.R. Annual report (1970–71)

TABLE VI. FERTILIZER DOSES BASED ON AVERAGE SOIL TEST VALUES FOR MAXIMUM AND ECONOMIC RESPONSE OF DIFFERENT CROPS UNDER DIFFERENT AGRO-CLIMATIC REGIONS

Crop		*Fertilizer dose at average soil test in kg/ha* (a) *Maximum response* (b) *Economic response*			*Total grain yield with application of fertilizer* (kg/ha)	*Response to fertilizer kg/ha (grain)*
		N	P_2O_5	K_2O		
Wheat (Kalyan Sona)	a)	156	93	26	4804	3084
(Ludhiana)	)	149	66	0	4668	2948
Wheat (Sonalika)	a)	147	87	0	6376	4183
(Jabalpur)	b)	140	76	0	6346	4153
Wheat (Hira)	a)	117	150	0	6215	2556
(Delhi)	b)	103	150	0	6193	2536
Rice (Sabarmati)	a)	150	150	100	5443	2694
(Delhi)	b)	130	150	100	5401	2652
Rice (IR. 8)	a)	176	138	24	4035	2199
(Rajendra Nagar)	b)	144	15	0	3681	1845

Source: I.C.A.R. Annual report (1970–71)

TABLE VII. EFFECT OF APPLICATION OF GYPSUM ON THE YIELD OF DIFFERENT CROPS.

Gypsum (tonnes/ha)	*Grain yield kg/ha*		
	Paddy	*Barley*	*Wheat*
0	2.37	0.40..	0.43
7.5	14.31	22.08	16.40
15.0	27.66	25.85	28.10
22.5	30.96	29.07	34.05
30.0	34.17	33.18	37.90

Note:— A replicated experiment was conducted at the farm of the CSSRI, Karnal. Gypsum was applied at the rate of 7.5, 15.0, 22.5 and 30.0 tonnes/ha before sowing of rice (Jhona 351). After the harvest of rice each plot was sub-divided into two. One half portion was shown with wheat and the other half barley without any additional gypsum application.

Source: Indian Farming, Vol. XXII(2):19.

normal sowing time. Graded bunds were found most effective for controlling erosion. The centres at Vasad, Agra and Kota have developed techniques for the reclamation of ravine lands. The studies on watershed management are being conducted at Ooty and Chandigarh. It is proposed to recognise all these centres into a Land and Water Conservation Research Institute.

Soil structure

Deep ploughing has been found to be most efficient method of improving the structure of many soils in the black soil and alluvial soil groups. Application of organic manures in quantities exceeding 20 tonnes/ha and combined with gypsum has been found to be the most effective for the purpose.

Water management

Water management has been a neglected technology in India. It is only in the last few years that the reorganised the ICAR initiated an effective programme of research on water management. Some of the results of research indicate that for improving the efficiency of water use of high-yielding seed balanced use of fertilizers, multiple cropping and appropriate agronomic practices including plant protection are essential. Water management studies on rice have shown that about half the water is lost in leaching. Due to poor management of soil and water about 40-60 per-cent nitrogen is lost from use by plant. There is no convincing evidence for use of continuous submergence. In fact, the best results are obtained with 5 cm. submergence accompanied with drainage at tillering. In cereals generally tiller initiation, preflowering, flowering and grain development are considered the critical stages for irrigation. In wheat irrigation at crown root initiation, earing and ripening is most essential. Four irrigations at the critical stages of growth produced more yield than the same amount of water applied at wrong times (Table IX). In the alluvial soil of Cuttack, irrigation of paddy at hair cracking stage of the soil gave 3 times as much efficiency as with continuous irrigation. The notion that high-yielding varieties requires more water than the local ones has been disproved. The results show that critical stages of growth is more important than the total water for them.

In high water table areas of Delhi, the contribution from the water table is enough to meet the requirements of water for wheat. For saline soils and for sandy soils, the greater frequency of watering is essential than for normal soils.

Conclusion

Last 25 years have seen tremendous change in Indian agriculture which has passed from the subsistance farming stage to the modern agriculture based on input intensive technology. The period marks the beginning of an intensive research on soil fertility, fertilzers, soil management and water management. Most of the significant changes in

TABLE VIII. YIELD PERFORMANCE OF OILSEED CROPS UNDER RAINFED CONDITIONS (q/ha)

Crop	*Bijapur*	*Rajkot*	*Akola*	*Anantapur*	*Hyderabad*	*Jodhpur*	*Mean*
Sunflower	6·0	10·7	11·1	7·5	7·4	6·3	8·2
Groundnut	4·0	4·7	5·2	5·9	4·3	4·1	4·7
Sesamum	2·0	1·3	2·6	2·9	2·6	2·3	2·6

Source: All India Coordinated Research Project on dry land Agriculture. (Unpublished).

soil and water management technology have come in the last six years. It is realised that as the intensity of cropping increases and food need increases, the variety and complexity of problems of soil and water will increase. Thus, the future of Indian agriculture depends to a great extent on how we manage our natural resources particularly the soil and water.

TABLE IX. CRITICAL STAGES FOR IRRIGATION IN WHEAT CROP GRAIN YIELDS Q/HA

S. No.	*Stages of wheat growth at which irrigation was withheld i.e., water stress at a particular stage*	*Total number of irrigations*	*Bichpuri (Agra) Kalyan Sona*	*I.A.R.I. (New Delhi) Kalyan Sona*	*Kanpur Kalyan Sona*	*Powerkheda Kalyan Sona*	*Ludhiana Kalyan Sona*
1.	No stress	6	65·4	50·8	58·1	40·6	41·2
2.	Late jointing	5	51·6	47·3	52·2	31·5	33·5
3.	Crown root initiation (CRI)	5	38·7	41·6	44·4	28·6	30·5
4.	CRI + late tillering	4	37·5	36·8	35·3	19·3	17·3
5.	Milk + Dough stage	4	29·0	44·6	38·4	34·5	36·8

Source: Coordinated wheat research scheme—Agronomic. (Unpublished)

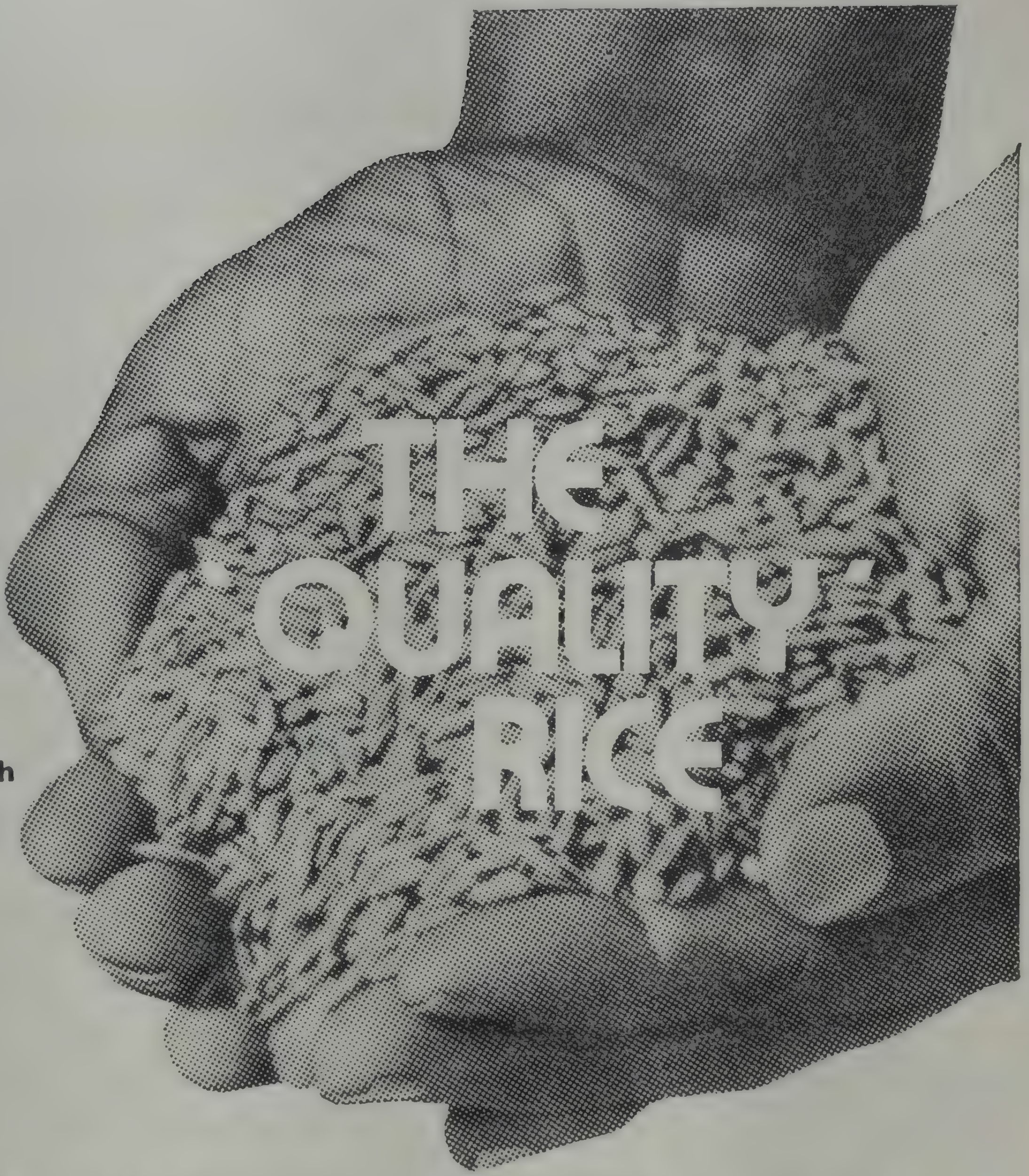
AGRICULTURE CANNOT WAIT

CONTINUED FROM PAGE 15

We witness today two major kinds of agricultural growth in the world. In one system, like that prevailing in North America and Europe, more and more land is being cultivated by less and less number of people and farming is therefore a labour-displacing occupation. This has been achieved through extensive mechanization and highly organised management. In contrast, in our country, agriculture has not only to be a source of food to the people but it has also to be for many years to come the most important instrument of economic growth and productive employment. To achieve agrarian prosperity, an increase in the *per capita* productivity is essential.

Four Major Revolutions

Modern agriculture rests upon four major revolutions: (i) agronomic (including genetic), (ii) chemical, (iii) engineering and (iv) management. It is only when all these four revolutions are synchronized in a perfectly coordinated manner that agriculture becomes highly efficient and competitive. While we may be justifiably happy at the progress that has been achieved during the last 25 years, the country needs even more significant results in the years to come. The investment on agricultural research and education made in the last few years will start giving a "pay off" only in the next few years. A dynanic poduction programme can be sustained only by a dynamic research and training programme. Unless the many complex and urgent problems arising from deficiencies in soil fertility, inadequacies in water management, poor pest control, improper storage and marketing arrangements and problems in animal health, nutrition and genetics are all faced and solved soon, the euphoria caused by the Green Revolution will be short-lived. Jawaharlal Nehru's statement "Agriculture cannot wait" is even more relevant today than when it was made 25 years ago.



Extensive research has now proved that rice needs Potash throughout the growth period and not just during the initial growth stage. That's why scientists today recommend split application of Potash instead of the conventional single basal application. 'Split application' vastly increases the yield, improves the quality. Here's how it works:

a) The first basal application of Potash along with Nitrogen and phosphate helps 'early establishment'.
b) The second dose of Potash with Urea, 20/25 days after basal dressing, accelerates 'tillering'.
c) The final top dressing of Potash with Urea after another 20/25 days results in the high increase of yield and weight of grains.

So for best results, instead of using the entire quantity of Potash in one single basal application, split it into two or three doses as suggested.

Potash is good for rice other ways too. It counteracts the ill-effects of excessive Nitrogen, improves resistance to pests, diseases, drought, frost and lodging.
Higher yield of better quality rice—thanks to split application of Potash.

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Panorama of

INDIAN CROP IMPROVEMENT RESEARCH AND DEVELOPMENT PROGRAMME

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New Delhi

AFTER India became an independent country in 1947, the late Prime Minister, Shri Jawaharlal Nehru, announced that the country should become self-sufficient in its food requirements as soon as possible. Several steps were taken, with varying degrees of success, towards the attainment of this goal. A brief account of these is presented here to give to the reader a panoramic view of Indian agricultural research and development during the last twenty-five years.

Grow More Food Campaign. One of the first steps was the launching of Grow More Food Campaign. The administrators and agricultural extension workers were asked to bend their energies to bring about a rapid increase in production with the help of increased inputs and efforts by way of improved seed, greater use of compost and farmyard manure, green manuring and better cultivation practices. Considerable investments were made for developing more irrigation through river valley projects and wells.

Agricultural Extension. It was soon realised that the task of improving agricultural production could be solved only if the millions of farmers in the country could be moved to take decisions and actions needed for increased production. No amount of planning and instructions at higher levels would help. To reach the millions of farmers and help them with adequate knowledge about the agricultural technology which would enable them to increase their producion and profit was a colossal job. This was attempted through the establishment of the Community Development Project which provided a framework for rural development programmes. According to this project the country was divided into five thousand and odd development blocks, each comprising about 100 villages or a population of about 60,000-70,000 persons. Each block was provided with an extension set up to help develop the several activities which are necessary for the prosperity of rural areas. During 1952 and 1963 the entire country was covered by these blocks. The key man in the Project was the multipurpose Village Level Worker (VLW) or Gram Sevak through whom the different programmes of the various government departments, relating to agriculture, cooperation, adult literacy, health and sanitation were channelised. However, the impact of the Project was far below expectation and foodgrains production maintained a slow rate of progress of about 3 per cent per annum. This increase was due more to increase in the area brought under crops rather than to increase in productivity.

Reorganization of Agricultural Research

It had long been recognized that improved agricultural technology stems from basic and applied research, and it was in order to foster productive research programmes that the Indian Council of Agricultural Research (originally known as Imperial Council of Agricultural Research) was established in 1929. However, the role assigned to ICAR to promote and coordinate agricultural research throughout the country was nullified to a large extent due to the existence of a number of Commodity Committees which operated independently of ICAR and of one another and tried to organize and finance research on the improvement of the different commercial crops with which they were concerned.

This set up of agricultural research was considered to be unsatisfactory. Therefore some expert teams were appointed, from time to time, between 1954 and 1963, to examine the set up and recommend improvements needed. Based upon the recommendations of the teams it was decided to reorganize the agricultural research in the country. The process is still going on.

Among the main changes under the reorganization have been the abolition of the several Commodity Committees and the transfer of their research functions, along with the assets including the research stations or institutes established by them, to the ICAR, Also the Central Research Institutes, which were directly administerated by the Government of India as subordinate offices, were transferred to the ICAR and they became the constituent units of the Council. The Vice President of the ICAR, who used to be a senior officer from the administrative service, was replaced by a scientist and the office was designated a Director-General.

Agricultural Universities

The States of Indian Union had been handling a major part of agricultural research and education and each was trying to develop crop improvement programmes with its own funds supplemented with funds from the ICAR and the Commodity Committees. An important development which was initiated during the late fifties was the establishment of Agricultural Universities. About this time the Indian Agricultural Research Institute, New Delhi, which was already an important centre of agricultural research and post-graduate education, was greatly strengthened by the establishment of Post-Graduate School in collaboration with the Rockefeller Foundation and assuming the status of a deemed University. Two other Central Research Institutes, Indian Veterniary Research Institute, Izatnagar (Bareilly) and National Dairy Research Institute, Karnal, also expanded their programmes of research and education.

Agricultural Universities

The States, most of whom had established their own agricultural colleges and research institutes, one by one began to adopt the recommendation first made in the Report of the University Education Commission which was headed by Dr S. Radhakrishan to the effect that there should be established Rural Universities in India. This recommendation was endorsed by the first Joint Indo-American Team (1954). Most of the States have now Agricultural Universities with the avowed aim of bringing about integration of agricultural teaching, research and extension to ensure development of appropriate agricultural technology and its flow to the farming community.

Coordinated Research Projects

The agricultural research programme in India has been rapidly gaining in strength and effectiveness by forging a partnership in research along the state and central institutions through the all-India coordinated projects. It is a commendable endeavour towards planning and implementing agricultural research programmes on a national basis. These projects have been drawn up taking into account facilities available at every place, supplementing these wherever necessary, with finance provided by ICAR, and making the best use of the available talent irrespective of where it is located. The projects emphasize problem-oriented research, provide intensification of efforts at selected centres to meet the needs of areas covered by distinct agro-climatic regions rather than on the basis of individual states. To ensure coordination, a Project Coordinator, of recognized merit and leadership qualities, has been provided in each project. The results have been very gratifying. These projects cover all important food and commercial crops, and fields of agronomy, soils and water management as well as of animal sciences.

Partnership in research is now being extended to some of the international institutes also, such as the International Rice Research Institute, Philippines, and the International Institute of Wheat and Maize Improvement (CIMMYT), Mexico.

Intensive Agricultural Districts Programme. In spite of the improvements in agricultural research the rate of increase in agricultural production continued to be slow in the fifties. A critical review of the situation by an expert team of Ford Foundation in 1959 led to several suggestions one of which was the need to concentrate efforts in selected areas where conditions for rapid increase in production were favourable. Following this suggestion one district in each State was selected for the Intensive Agricultural Districts Programme (IADP). In these IADP districts the extension set up was greatly strengthened and a package approach, in which all the factors of production, viz. production requisites, credit, farm planning, technical advice and appropriate extension methods, were tied up together, was adopted.

Fertilizer Use. Among the production requisites in the IADP fertilizers were of vital significance. Fortunately, the extension workers and farmers were becoming aware of the crucial role which fertilizers can and must play to enable India, which had been importing several million tons of food grains every year, to become self-sufficient. Awareness of benefits of fertilizer use resulted from a vast programme of fertilizer demonstration which was initiated about the mid-fifties. Supported by a programme of simple fertilizer trials on fields of farmers, the several hundred thousand demonstrations conducted during the second decade following Independence resulted in a very considerable demand for fertilizers. And whereas in 1950-51 the total consumption of fertilizers interms of nutrients was only 69,000 tonnes, during the last twenty years it has increased almost forty times.

High-Yielding Varieties

In a significant measure the rapid increase in fertilizer use has been due to the breeding of high-yielding varieties of some of the cereal crops. The first to come on the scene were maize hybrids which were extensively demonstrated among farmers with the help of USAID and which created considerable excitement among them due to the very high yields and profits which they could give. This has started building among farmers a faith in new technology and hope for the future. Soon there were high-yielding hybrids of *jowar* (Sorghum), *bajra* (pearl millet), followed by the dwarf wheat and the dwarf rice varieties. These have ushered the "green revolution" in India. The Governments at the Centre and in the States have been operating a High-Yielding Varieties Programme to bring the maximum possible area under such varieties. The most notable success has been in the case of wheat whose production has doubled during the last five years, making the country independent of wheat imports. The HYV programme could not have been possible without the import of large quantities of fertilizers because the production within the country has been much below the rapidly increasing demand. The Government of India wisely decided to allocate large amounts of foreign exchange on a basis of priority for import of fertilizers to support the programme. Although the foodgrains production in India recorded an all time high of about 108 million tons in 1970-71, this level is till much below the Fourth Plan target. Large increase in production can be expected from rice which has so far not shown marked increase even though it occupies the largest acreage (about 38 million hectares) among the food grain crops. Any dramatic increase in food grains production in the near future can now be expected from rice because of the new high-yielding varieties developed at the Central Rice Research Institute, Cuttack, and under the All India Coordinated Rice Improvement Project, which combine high-yielding ability with more acceptable grain quality and better tolerance to some of the diseases and pests than the earlier developed varieties. In order to speed up their spread among rice farmers a Minikit Programme, which aims at making available 2 kg seed of two or three varieties, considered most suitable for particular areas, to each of several thousand farmers in each district has been started. The reaction of farmers to particular varieties will enable the extension workers to choose the best varieties for particular areas besides ensuring for the varieties a rapid spread among farmers. An aggressive seed multiplication programme will be formulated on the basis of the acceptance or otherwise of particular varieties by farmers.

Plant Protection. The HYV programme has brought to the forefront the importance of plant protection measures to ensure the realization of high yield potential these varieties possess. Conditions favourable for high yields also favour diseases and pests. Use of pesticides is often cumbersome and costly. Hence considerable emphasis in the crop breeding programmes is being given to the breeding of disease and pest resistant varieties. Notable success has been achieved in some crops, such as rust resistance in wheat, resistance to tungro virus, blast fungus and gall-midge in rice. Use of pesticides is on the increase and sizeable industry of manufacture of pesticides in the country has developed.

National Demonstration. In order to demonstrate that very high and profitable yields through intensive farming can be secured by farmers a programme of National Demonstration was started in 1965. This programme commits agriculture research workers to directly help selected farmers to try for themselves the best research findings for maximum production in a unit area in a given period. This has opened up new vistas of crop production and is of considerable educational value not only to farmers and extension workers but also to research workers. The programme is now operating in 75 districts. Spectacular yields in a number of demonstrations have been obtained and this has fired the imagination of the farming communities. Yields of above ten tonnes a hectare have been quite common.

Multiple Cropping

A number of experiments designed to test the possibilities of growing two, three or four crops a year have been carried out under a scheme of model agronomic experiments. Total grain yields of 10 to 15 tonnes a hectare during a year growing three crops have been secured. Cropping patterns to develop an agronomic technology suitable for farmers with different resources will be developed on the basis of these experiments. Keeping in view the long term effects which are likely under intensive cropping envisaged under HYV and multiple cropping programmes experiments have been started to monitor the changes in soil as a result of intensive use of fertilizers, pesticide and water involved in such cropping. Already evidence of micronutrient deficiency arising out of large offtakes of plant nutrients, present in the soil and applied through fertilizers for high level production has been forthcoming from several districts. Thus zinc deficiency has already started figuring prominently in some wheat and rice growing districts. In many fields the application of zinc has given marked yield increases. In Haryana the increases ranged from 22 to 77 per cent in five cases and below 8 per cent in two cases. Yield increases varied from 12.4 to 29.4 quintals per hectare. In paddy, hybrid maize and hybrid sorghum, significant responses to zinc have been reported from Uttar Pradesh, Bihar, Andhra Pradesh and Gujarat. The coordinated scheme on micronutrient studies is studying the problems which exist and which are likely to arise as a result of intensive cropping.

Dryland Agriculture

Intensive cultivation is possible in areas on good rainfall and those with adequate irrigation resource. But the nearly 50 million hectares, having a rainfall of about 1150 mm or less, have to depend upon a dryland type of agriculture, growing a single crop a year and characterised by unstable, low yields. In these areas large acreages are cropped to many of our important crops, such as cotton, pulses, oilseeds and millets. Suitable technology, using soil and water conservation measures, judicious fertilizer use, short-duration varieties of important crops, proper tillage,plant protection measures, etc. needs to be developed. A Coordinated Project on Dryland Agriculture has been started at 24 selected research centres. The project is assisted by five Canadian experts. Pilot projects to demonstrate the benefits of using appropriate technology indicated research have been started in the vicinity of research centres. On the success of the pilot projects will depend the strategy which will be adopted for a balanced development of agriculture in the country as a whole so that the dryland areas are not left out in the goal toward better production and prosperity and thereby suffer social and economic disabilities compared to the irrigated areas.

New Crops

Prospects offered by some crops relatively unimportant or not previously grown, in the country appear to be bright. One of these is sunflower a few varieties of this crop were imported two years ago. Some of these are of particular interest to India as they have given very attractive yields under conditions of dryland agriculture. Optimum agronomic schedules for both irrigated and unirrigated cultivation for different soil and climatic conditions are being worked out at a number of research centres. Another crop is soyabean which has long been grown as a food grain crop in the lower Himalayan hills in some of the Garhwal and Kumaon districts of Uttar Pradesh. Introduction of varieties from USA, where a considerable amount of research has produced a large number of varieties of high yields, and their evaluation in a coordinated project, has led to the identification of some varieties of great promise. Among these may be named Bragg, Lee, Clark 63 and Hill. However, germination of seed of soyabean is generally found to be poor and this has greatly hindered the programme of a rapid popularisation of the crop as an oilseed which has already attracted the attention of the oil industry.

Sugarbeet is another crop which has shown possibilities of profitable cultivation in India. A scheme for the development of sugarbeet in the north western plains zone in the States of Punjab, Haryana, Uttar Pradesh and Rajasthan, and in selected areas in Maharashtra has been under way during the last two years.

Commercial Crops. There are many more crop improvement and development programmes which have not been mentioned above. There is a whole range of commercial crops, oilseeds, sugarcane, cotton, jute and tobacco, all of which are receiving attention under all-India coordinated Projects and have shown varying degrees of success. Outstanding among these are the Hybrid 4 cotton developed in Gujarat and the high quality Sujata and MCU 5 developed at the Regional Research Station, Coimbatore. In sugarcane, the varieties Co. 658, Co 740, C9 975, Co 996, Co 1148 and BO 17 have been notable contributions of research. Possibilities of a breakthrough in cane production are indicated by a recent finding that sugarcane yields in many parts of the country are greatly held down by some viruses which cause ratoon stunting and grassy shoot in the sugarcane crop. Even apparently healthy looking canes are, in many cases, infected by one or the other of the viruses and fail to respond fully to fertilizer application and other improved practices. The yield barrier, imposed by the viruses, can be removed with the help of heat treatment of sugarcane seed (setts) developed at the Indian Institute of Sugarcane Research, Lucknow. The benefits of this treatment, which completely eliminates the viruses from the infected setts, is now being demonstrated to farmers. Some of the sugarcane factory farms have already installed the heat treatment units designed by the Institute at Lucknow and are benefiting from the seed treatment. A sizeable project to produce foundation seed of sugarcane by installing heat treatment units at a number of centres operated by trained and skilled workers has now been formulated and is expected to shortly go into operation.

Plantation, Tuber and Horticultural Crops. There are many more crops on which coordinated projects for their improvement have been initiated during the last 3-4 years. Among these may be mentioned the plantation, tuber and horticultural crops. In coconut, hybrids of Dwarf × Tall have shown marked superiority in yield and wilt resistance compared to the traditional tall varieties which have been going down in yield due to progressive increase of wilt disease. Most of the diseased trees give hardly one-third the number of nuts expected of a healthy tree. The hybrids, showing higher resistance to wilt have given, on an average, 111 nuts per palm as against 26 nuts from 'West Coast Tall', and could be used for replacing the latter variety now growing in Kerala, to the immense benefit of the state. Among tuber crops the new varieties of potato, such as Kufri Chandramukhi, Kufri Jyoti and Kufri Muthu are excellent products of research. Hybrid varieties of tapioca, like H 165, H 226 and H 97, are outstanding in yielding ability.

Research on the improvement of vegetables and fruits has been greatly strengthened with the help of coordinated projects which have made good use of the increased research facilities for horticultural crops developed at the Indian Agriculture Research Institute and in some of the States, and of the lately established Indian Horticulture Research Institute, Bangalore.

There are several fields of research related to increase in crop production which depends upon proper management of soils and water, use of good agronomic techniques, suitable implements and machinery and control of pests, diseases and weeds. That major findings in these fields have not been mentioned in this article does not mean that they are less important. The article aims at giving a panoramic view of the main events which have influenced crop production during the last twenty-five years. Hence no mention has been made of the important developments in the fields of livestock research and development nor of fisheries. The account of crop research and development given here would justify hope that India will be able to continue to achieve large increases in agricultural production in the coming years. This hope is based upon the accomplishments in agricultural research and its application in the field. Let it not be forgotten that all this was made possible because of the contribution of many scientists who are able to perform many of the needed tasks because of the education and training they were able to receive from the many agricultural colleges and research institutions in India, the most notable of which, in the field of post graduate training and research, has been the Indian Agricultural Research Institute, New Delhi. This Institute and the several Agricultural Universities are now helping the country by producing a large cadre of young agricultural research workers and teachers who are required in increasing numbers to many of the positions in the fields of teaching, research and extension being created to hasten the development of the country. All this increase in output of technical personnel and its utilization in research and development programmes bespeaks of a progressive and purposeful outlook on the part of men who are at the helm of affairs in the Governments at the Centre and in the States, and who have been helping to take the country along the path of plenty and prosperity. That the contribution which many young scientists and technologists, several times more in number today than they were twenty-five years ago, would be able to make in the years to come would be infinitely greater can be safely assumed. For, have they not a resurgent India and the achievements of today to inspire them to aim at even greater achievements tomorrow?

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A CHAPTER OF PROMISE OF THE QUARTER CENTURY

GROWTH OF AGRICULTURAL EDUCATION

O. P. GAUTAM
Deputy Director-General, I.C.A.R., New Delhi

ORGANISED instruction in agriculture in India began as early as the beginning of this century when five agricultural colleges were established during 1907 offering diploma courses. These institutions were later upgraded to degree level. In the field of Veterinary Sciences the Madras, Bombay and Calcutta Veterinary Colleges were the first to be established. The earliest post-graduate courses were organised towards the early twenties and it was only about 1930 that the post-graduate colleges and institutes secured recognition for imparting training at M.S. and Ph.D. levels in agriculture. Central Institutes like the Indian Agricultural Research Institute and Indian Veterinary Research Institute, which were primarily developed as research institutes and which over the years developed certain educational functions, continued to offer specialised post-graduate courses, in Agriculture and Veterinary Sciences respectively, leading to awards of diplomas or certificates. All agricultural education was closely linked with available Government jobs. There were practically no problems of employment of trained personnel.

Development of Agricultural Education during post Independence period

When India attained Independence in 1947, there were 17 agricultural institutions offering degrees. Although higher agricultural education was costly and the resources available were rather limited, a large number of new agricultural colleges sprang up during post-Independence decade under pressure of regional interests and in response to accelerated demand for agricultural graduates during the First Plan period. The number of agricultural colleges went up by about three times and that of veterinary collegs almost doubled, during the period 1951 to 1961. Intake capacity and output of degree colleges reached a peak in 1965-66. In that year, 90 colleges (70 agriculture plus 20 veterinary) admitted 11,562 students and turned out 6,250 graduates. Today, there are 93 degree colleges in all but the enrolments are declining due to unemployment of agricultural graduates with the .result that a number of State Governments had to reduce admissions by up to 50 per cent. Although most of these institutions came up as Government colleges under the administrative control of Departments of Agriculture or Animal Husbandry, in some of the states like Uttar Pradesh, a number of affiliated private colleges sprang up without much planning or preparation. Many of these colleges did not have adequate farm, laboratory and library facilities. Uttar Pradesh alone accounts for about 40 per cent of the total intake capacity.

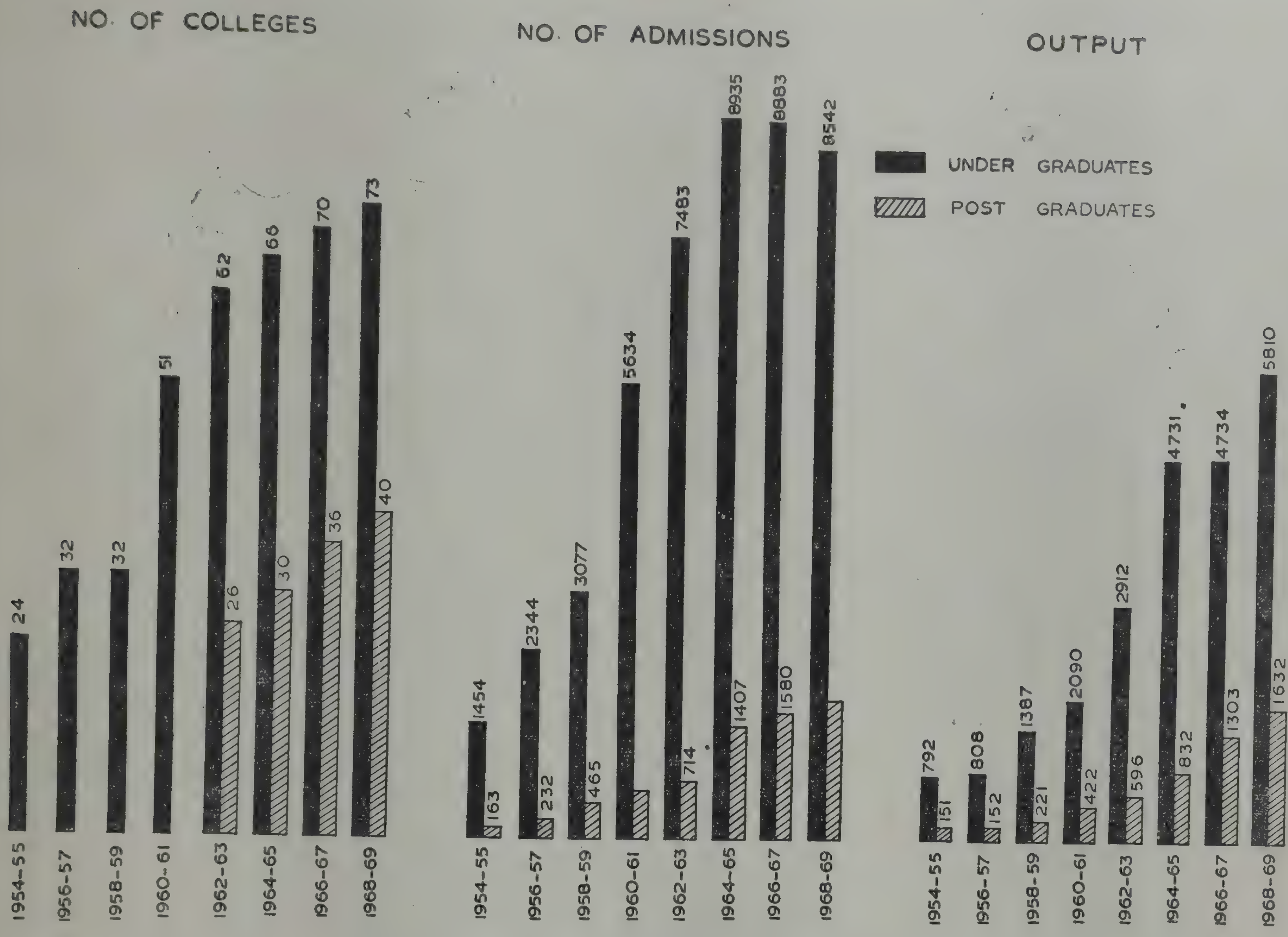
The number of post-graduate agricultural colleges increased from 5 in 1951 (enrolment 167) to 26 in 1962 (enrolment 654) and to 40 in 1971. Only one veterinary college offered post-graduate courses in 1956 (enrolment 9) but in 1961 the number went up to 5 (enrolment 123) and today in 1972 there are 20 veterinary colleges admitting about 300 postgraduate students. This expansion of post-graduate education, unlike under-graduate education, has continued until recently although it now appears to be levelling off. There has been, however, a sharp increase in the number of students preparing for the doctorate. Currently, about 25 per cent of agricultural and veterinary graduates go on to post-graduate studies.

While enrolments at some of the affiliated sub-standard colleges have shown abrupt decline, agricultural universities continue to attract larger number and better students. Obviously the element of competition between institutions has come into play and performance of the sub-standard institutions has started recoiling on them.

Progress of agricultural education during the past three plan periods are shown in Table I.

According to statistics published by UGC the total enrolment in agriculture and veterinary has gone up by about 16 times since 1960. The numbers of Bachelor's and Master's degree holders have been increasing at the rate of about 14% per annum since 1950. The post-graduate enrolments have registered an increase of about 5.8 times over those in 1950, but those in research have gone up by about 14 times over 1960 figures.

Most of these colleges referred to abovewere primarily concerned with the training of agricultural graduates. The State Departments of Agriculture and Community

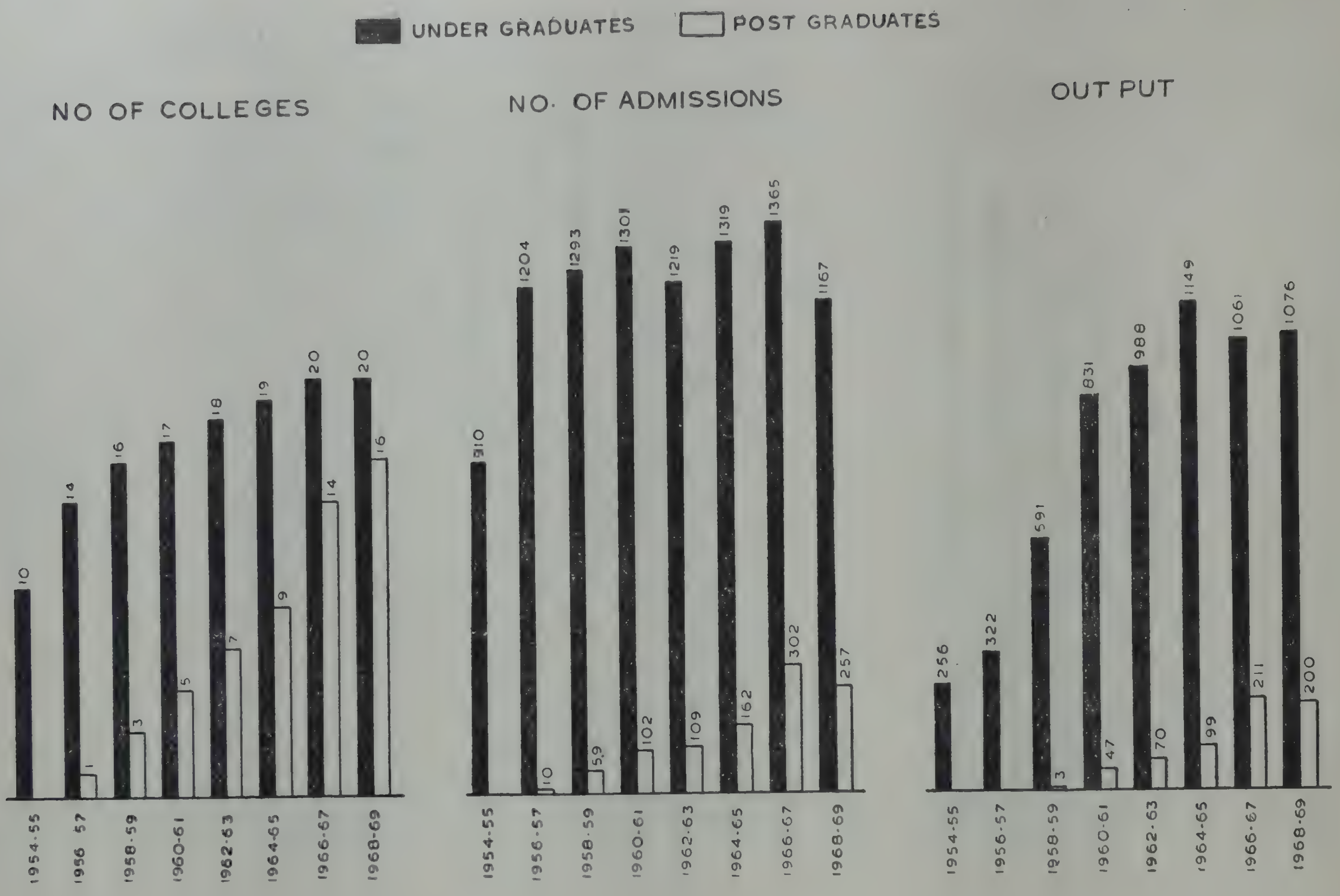


Progress of agricultural education in India-1954-1969

Development executed the programmes of research and extension respectively. The relationship between agricultural colleges and research departments, therefore, was not close enough to ensure maximum transfer of information in practice. The production technology developed at these educational institutions did not keep pace with the fast changing requirements of our agriculture. As a result of this it became hard to convince State Governments that investments in agricultural education and research would pay lasting dividends. The rate of investments in agricultural education, therefore, remained deplorably low, virutally stagnant. Moreover, this expansion took place along traditional pattern. It was not oriented to meet the needs of economic progress and change that was overtaking the country. It was soon realised that both the system of education as well as the set up of the institutions in the field of agriculture and animal sciences needed to be reorganised, if it was to serve as effective vehicle of agricultural progress and development.

Reorganisation of Agricultural Education and Development of Agriculture Universities

The need to bring about a rapid increase in food production in the years immediately following Independence necessitated re-examination of the existing system of agricultural education. It was soon realised that the goals of increased production could be achieved only through application of science and technology to agriculture and that trained personnel were vital for developing science based agriculture. Accordingly, Government of India appointed in 1948-49 the University Education Commission headed by Dr. S. Radhakrishnan our former President, which examined the entire pattern of higher education in India and made recommendations for improving it. Recognising the weakness of traditional system and the need for linking programmes of agricultural education with production progammes, this Commission suggested in 1950, the establishment of of Rural Universities. This turned out to be a most far-reaching recommendation, for it represented the



Progress of Veterinary education in India-1954-1969

germ of the idea that led to the establishment of agricultural universities in India.

After a careful consideration of the different systems of agricultural education which were in vogue in different parts of the world, Government of India came to the conclusion that the Land Grant College system of education in the U.S.A. provided the most promising basis for developing a suitable Indian model. The model now adopted for agricultural universities in India is the one which has been developed and adapted to suit the local conditions, resources and local genius. The model envisages among other things, state-wide responsibility for teaching, research and extension education in agriculture including animal science and home science complex of constituent colleges under single administration, complete integration of research, education and extension programmes, sufficient flexibility to enable quick response to changes and reforms, autonomy in functioning and adoption of internal evaluation system.

With a view to providing a model legal base to agricultural universities, Government of India appointed an Agricultural Universities Committee in 1960. The report of the Committee submitted in 1962, provided the guidelines for developing the Model Act by the I.C.A.R. This Model Act given out in 1966 provides, in sufficient details, the legal framework for the development of an Agricultural University in India.

By now the concept of agricultural universities forms an integral part of the National Policy on Education. It has been accepted that at least one Agricultural University may be established in each state. Seventeen Agricultural Universities have already come into existence, the first one being the Uttar Pradesh Agricultural University in Pantnagar in 1960. Out of the total 93 agriculture and veterinary colleges in the country today, about 50 are constituent colleges of agricultural universities. The Indian Agricultural Research Institute where the new system of post-graduate education was first adopted in 1958, has the deemed university status.

TABLE 1 : PROGRESS OF AGRICULTURAL EDUCATION DURING THE THREE PLAN PERIODS (1956-71)

Particulars	*1955—1956* *UG*	*PG*	*1960—1961* *UG*	*PG*	*1965—66* *UG*	*PG*	*1970—71* *UG*	*PG*
Agricultural Colleges								
1. Number of Colleges	31	Not available	51	26	70	36	72	42
2. Enrolment	1,969	223	5,634	607	10,008	1,634	11,500	1,800
3. Output	886	141	2,090	422	5,250	1,191	8,050	1,190
Veterinary Colleges								
1. Number of Colleges	14	Not available	17	5	20	12	21	16
2. Enrolment	1,269	Not available	1,301	102	1,501	250	1,050	300
3. Output	268	Not available	831	47	990	128	1,000	240
Agricultural Engineering Colleges								
1. Number of Colleges	1	—	1	—	5	1	8	4
2. Enrolment	30	—	30	—	320	17	250	60
3. Output	18	—	26	—	128	14	230	40

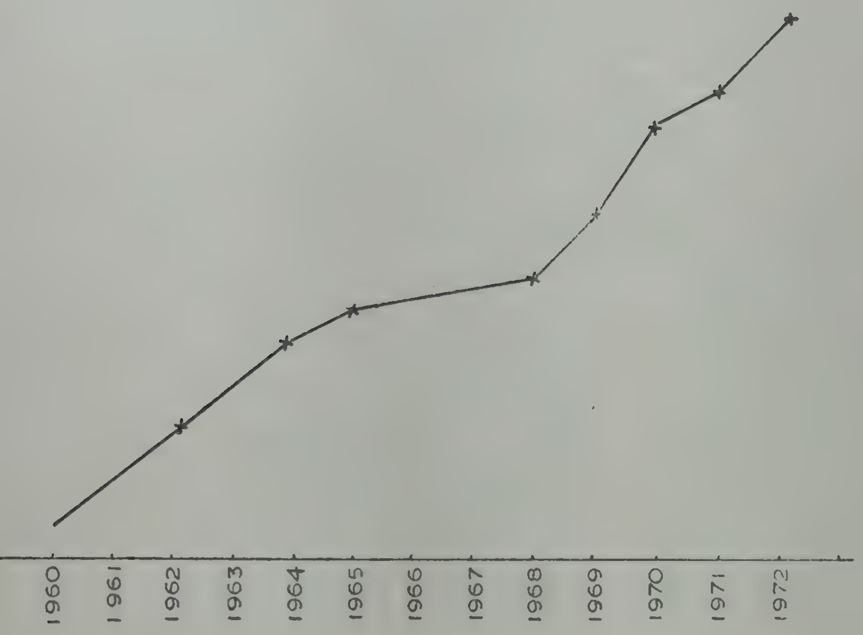
UG : Under-Graduate

PG : Post-Graduate

The Indian Veterinary Research Institute and the National Dairy Research Institutes continue to offer M.Sc. and PhD. degrees of affiliating universities like the Agra and Punjab Universities.

Agriculture being the State subject these Universities have been established by the respective State Governments, through legislation. While the State Governments remain to be the main source of financial support, a substantial contribution is made by the I.C.A.R. for the development of these universities. To start with, the assistance was given on the U.G.C. pattern which required a counterpart investment from the State/University. However, with a view to developing these service-oriented institutions to an effectively functional stage in comparatively shorter period of time, a new pattern of assistance has been adopted, which enables the I.C.A.R. to give assistance on 100 per cent basis for 16 selected items of development with an overall ceiling for the plan period as well as for each item.

The establishment of agricultural universities is one of the most significant landmarks in the history of agricultural education in India. I.C.A.R. has played from the very beginning the most significant role in bringing about these educational reorganisation. In addition to the local resources, foreign technical assistance was also arranged and utilised for the development of Agricultural Universities. Over 500 teachers and research workers from Colleges and Universities in India have received advanced training abroad under these various programmes. With the creation of internal competence and facilities for such training within the country, this programme is being substituted by Joint Training Programme and Inter-institutional programmes between Indian Universities and Institutes. With the same objective, the project for the stablishment of 'Centre of Excellence' has been started recenly with UNDP assistance. Also a programme of organisation of Summer Institutes has been taken up for in-service training of teachers and researchers with a view to updating the knowledge and keep them posted with recent advances in the various agricultural sciences and sciences related to it. There is a perceptible improvement in the quality of education. There are more competent teachers, better equipped libraries, laboratories, and farms and there is better academic preparation in the case of teachers. The internal examination system is geared for continued preparation on the part of both students and teachers. The reform in agricultural education introduced in agricultural universities besides improving in quality has brought down to a large extent the wastage in higher education in agriculture. This not only saves costs but provides training opportunities for more students. These institutions today are serving as fountainheads of new knowledge earned through purposeful, problem-solving research and have become main centres of dissemination of useful know-



Growth of agricultural universities

ledge to the farming community. Some of the best training for farmers is offered by the agricultural universities. We are producing here a large number of functional specialists who have confidence born out of personal experience in successfully applying scientific knowledge to the solution of practical problems as well as those who have the competence to earn new knowledge that helps to enrich educational programmes.

With the good working conditions and incentives that they offer both to the faculty and the students, agricultural universities are providing opportunities for productive and prestigious work, are fostering unprecedented team spirit and a healthy change in the outlook of all the teachers, the researchers, the farmers and the administration. They are winning the confidence of both the farmers and the governments. They have already assumed leadership in sciences, education and extension in a number of cases and are producing future leaders for Indian agriculture. Their direct contribution to programmes like pedigree seed production, fertiliser-use and National Crop Demonstrations is highly impressive. Above all, they are aware that there is no substitute for quality and competence and for this they are striving ceaselessly. In this connection the inter-institutional collaboration needs special mention.

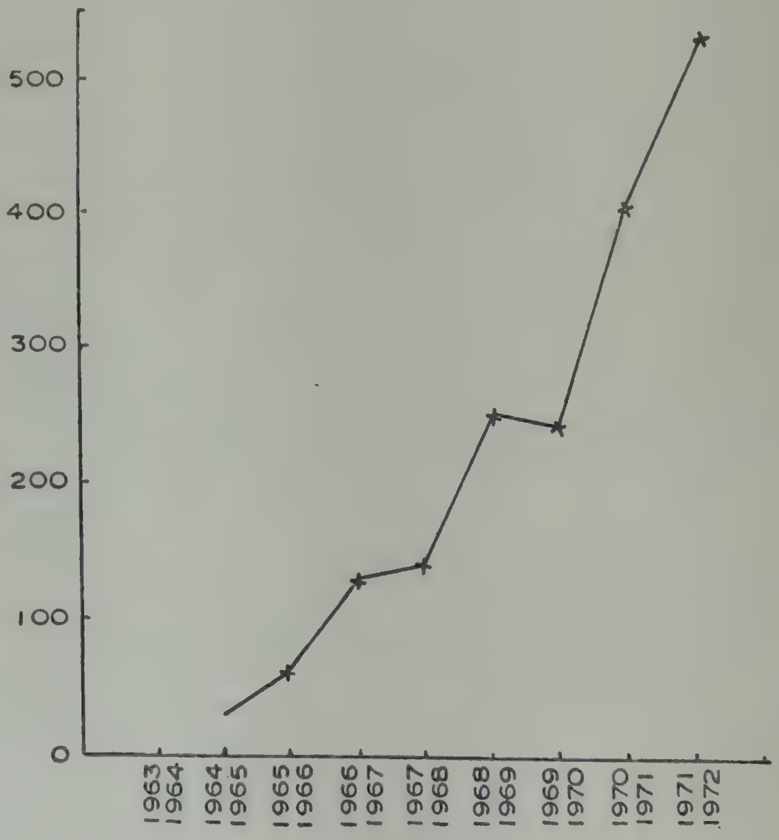
The concept of integration of teaching, research and extension has already proved its worth as demonstrated by the contributions made by the agricultural universities in such a short period.

Affiliated Colleges of Agriculture and Veterinary Sciences

Although agricultural universities have been established in most of the states, about one-third of the agriculture and veterinary colleges still remain outside this orbit and are affiliated to traditional universities. They account for about 40 per cent of the total output of agricultural graduates. The I.C.A.R., therefore, continues to give assistance for the development of such of these colleges which have the necessary potential for development. As in the case of agricultural universities, assistance was formerly given as per the U.G.C. pattern. According to the revised pattern of assistance recently adopted by the I.C.A.R., affiliated colleges will also receive assistance on 100 per cent basis on 11 selected items of development with an overall ceiling for the plan period as well as for each item. With a view to bringing about the uniformity, introduction of 3 year degree course after 12 years of schooling has received special attention in the case of States/Universities where it had not been adopted so far. It is intended to extend, through I.C.A.R. assistance, the concept of integration of teaching, research and extension to these colleges also.

Growth of Dairy Education in India

The establishment of Imperial Institute of Animal Husbandry & Dairying in 1925 at Bangalore (later known as the Indian Dairy Research Institute) was the first landmark in the history of Dairy Education in



The ICAR Financial assistance for the development of agricultural universities (in lakhs)

India. The first course in dairy farming was started in 1924. Later the Indian Dairy Diploma (IDD) course of two years' duration was started. In 1945, the Associateship course was initiated. The Institute has also been admitting Honorary Research Workers who, on the basis of their research work, could earn M.Sc. and Ph.D. degrees of affiliated Indian universities. In 1955, the headquarters of the Indian Dairy Research Institute was shifted to Karnal and the Institute was renamed as the National Dairy Research Institute. The Dairy Science College was organised as part of NDRI in 1957. The degree course in dairying was first introduced in that year itself under the auspices of Panjab University. This was a four year degreee course. This course was later divided into two branches, viz., B.Sc. (Dairy Husbandry) and B.Sc. (Dairy Technology) in 1961. This was also the year for starting M.Sc. Dairy course. From the same year the IDD training was bifurcated into Indian Dairy Diploma (Dairy Husbandry) and (Dairy Technology). The education and research functions of the eight Divisions of this Institute are fully integrated although the Institute has a separate Division of Dairy Education and Training largely with coordinating functions. During the Fourth Plan period dairy education at N.D.R.I. has further been strengthened adding 3 more divisions, viz., (i) Dairy Cattle Nutrition & Physiology, (ii) Dairy Cattle Genetics & Breeding, and (iii) Nutrition and Dietetics. So far about 70 IDD, 200 B.Sc. (Dairy,)150 M.Sc. (Dairy) and 20 Ph.D. students have passed out from National Dairy Research Institute. The Institute continues to remain the strongest single centre of education and has provided most of the trained man power available in this field in the country.

The Dairy Science College at Anand started in the year 1961-62 is the only other Dairy Science college in the country. The college prepares students for IDD course and B.Sc. (Dairy Science) degree of the Ballabh Vidyapeeth, Anand. At present IDD course is offered at 5 centres including NDRI and Anand.

Growth of Fisheries Education in India

Until the fifties, fisheries departments recruited graduates of zoology or biology. Some of them organised in-service training courses and also started polytechnics to award diploma courses in fishery technology and navigation, etc. The Central Government also started the Inland Fisheries Training course at Barrackpore and Marine Fisheries Training courses at Mandapam in Tamil Nadu. By and large these *ad-hoc* arrangements proved to be unsuccessful and had to be wound up.

It was only in 1958 that the Government of India decided to take steps to organise Fisheries education on a more permanent basis. The Central Institute of Fisheries Education at Bombay was set up in 1961 and the Central Institute of Fisheries Operatives, at Cochin in 1963. In the same year a post-graduate diploma course in Fish processing and technology was started at Mangalore by Government of Mysore with Japanese collaboration. Some of the Universities have since introduced Fish and Fisheries as a special subject in the M.Sc. course. Some have started full-fledged M.Sc. course in Marine Biology and Oceonography. In 1969, the Calicut University started a B. Tech. fisheries course and in the same year the University of Agricultural Sciences has started a fulfledged Fisheries College at Mangalore.

The Central Institute of Inland & Marine Fisheries training referred to above offer a number of Diploma and Certificate courses of duration varying from 6 to 15 months. Short courses of about one month duration in Fish Processing Technology are offered by the Central Food & Technological Research Institute, Mysore as well as under the Indo-Norwegian Project. There is, however, no doubt that fisheries education needs to be strengthened considerably to meet the increasing demand for trained man-power in this field.

Agricultural Engineering Education in India

The Allahabad Agricultural Institute was the first institution in India to offer in 1942 the courses leading to the Bachelor's degree in Agricultural Engineering of the University of Allahabad. Indian Institute of Technology, Kharagpur, started a similar degree programme in 1952. Six more constituent colleges of Agricultural Universities—UPAU (Pantnagar), University of Udaipur (Udaipur, 1964), PAU (Ludhiana, 1965), OUAT (Bhubaneswar, 1966), JNKVV (Jabalpur, 1967), and MPKV (Poona, 1969) have started an agricultural engineering college each. These colleges have an admission capacity of about 300 students per year and a total strength of about 1,200 students. About 1,000 students have already graduated from these institutions in the past. It is evident that all the engineering colleges are at present located in north India. There is room in the south. This regional imbalance in the growth of agricultural engineering education is responsible, at least partly, for the unemployment problem of agricultural engineering graduates witnessed during past few years and needs to be corrected as early as possible.

Home Science Education in India

Home Science education is not new and a large number of traditional universities have been offering education in Home Science for quite some time. However, in response to the need for orientation of Home Science education towards agriculture, three of the Agricultural Universities have organised constituent Home Science colleges after 1965. These are APAU, Hyderabad, PAU, Ludhiana and Udaipur University. At least five more agricultural universities have developed plans to start Home Science colleges in the near future.

These colleges are organised around four main disciplines —Food and Nutrition, Child Care and Development, Home Management and Clothing and Textiles.

One of the main hurdles coming in the way of the development and growth of Home Science education for farm women is the paucity of trained personnel as well as excessive mobility of staff.

Diversification and Specialisation in Higher Agricultural Education

With the advancement of Science and Technology and the need for greater degree of specialisation to tackle the new and complex problems that are coming up in the field of agriculture, there has been considerable diversification and specialisation in higher agricultural education in India. The subject of Agronomy which was organised only in late forties, as a distinct subject of Agriculture, has since developed into further fields of specialisation such as Crop Husbandry, Water Technology, Weed control, Plant Tissue Test and Soil Fertility. Likewise, the subject of Agricultural Botany has since grown into distinct fields like, Genetics, Plant Breeding, Plant Physiology, Plant Protection, Seed Technology and Horticulture. Horticulture has developed further into Pomology, Olericulture, Floriculture and Fruit Preservation. A number of new subjects like Food Technology, Human Nutrition, Business Management, Agricultural Credit and Nematology have come up in recent years. In the field of Veterinary and Animal Husbandry also new subjects like Poultry Science, Public Health, Animal Products Technology and Bio-chemistry have been added. With a view to reducing India's dependence for foreign training, the programme for the estabishment of 'Centres of Excellence' in selected but specialised areas has been taken up lately. Thus, there has been considerable spurt in the diversification and specialisation of agricultural education in recent years.

I.C.A.R. and Co-ordination of Agricultural Education

I.C.A.R. was established in the year 1929 in pursuance of the recommendation of the Royal Commission on Agriculture (1926). The main functions of the I.C.A.R. *inter-alia* are to coordinate, aid and promote agricultural research and education and to serve as a clearing house of information relating to these functions. Although the statutory authority for coordination, accreditation etc., of higher education rests with the U.G.C., in practice the coordinating functions in the field of technical, medical and agricultural education have been entrusted to the Central Ministry concerned, Accordingly, I.C.A.R., under the aegis of the Ministry of Agriculture, performs, for all practical purposes, the same role in relation to agricultural education as the U.G.C. does in the case of Basic Sciences & Humanities. The Council is responsible for coordination and promotion of higher agricultural education in the country. It provides incentives and leadership for the development of new and need based agricultural education programmes, introduction of educational reforms, and institutionalisation of educational innovations. One of the important functions of the Council is to achieve uniformity of standards of agricultural education between institutions. The ultimate goal is to provide well trained manpower needed to give a sound scientific and technological base to India's agriculture with a view to accelerate pace of agricultural development and social transformation. The main emphasis in the programmes of agricultural education is, therefore on achieving 'excellence' and 'relevance'. For this, the Council gives assistance to Agricultural Universities and colleges for their development programmes, such as construction of the laboratories, libraries, hostels and purchase of books and equipment. It also provides technical guidance in the development of curricular materials, revision of syllabi and production of books. Organisation of Summer Institutes and in service training programmes, award of scholarships and fellowships to the students, organisation of workshops, seminars and symposia and development of inter-institutional training programmes also fall under the purview of the activities of the Council. Provision of foreign exchange, foreign training of faculty members and acquiring the services of foreign experts are some of its other important activities

As mentioned earlier, the early post-Independence era witnessed a rapid growth of higher education in agriculture and it becomes necessary for the Indian Council of Agricultural Research, in its capacity as national coordinating agency for agricultural education, to play an increasingly important role in the maintenance and improvement of standards of agricultural education. Accordingly, Indian Council of Agricultural Research set up under its aegis, the Indian Council of Agricultural Education in the year 1951. The main functions of I.C.A.E. were (a) to co-ordinate agricultural education programmes (including education in animal husbandry and dairying) so that uniform standards might be achieved throughout the country, (b) to prepare modern syllabi for adoption by various colleges and (c) to advise the State Governments on problems of agricultural education and to develop a consensus with regard to reforms that needed to be introduced in agricultural education. The first meeting of the I.C.A.E. held at Hyderabad set up a Standing Committee with Dr. B.P. Pal as Chairman to ensure the follow up action and continuity of work between the Council meetings. Later, as per recommendations of the first Joint Indo-American Team the composition and functions of the I.C.A.E. were further modified in the year 1957. *Inter alia* a whole time Chief of Agricultural Education to serve as an ex-officio Secretary to the I.C.A.E. was appointed. A quarterly journal of the I.C.A.E. was also published from 1958 to 1964.

With the reorganisation of I.C.A.R. in 1966, in pursuance of the recommendations of the Agricultural Research Review Team (1963) and the formation of the Division of Agricultural Education in the I.C.A.R., I.C.A.E., has been replaced by the Standing Committee on Agricultural Education. This Standing Committee is assisted by the two Scientific Panels on Agricultural Education and Animal Sciences Education. According to the recommendations of the Education Commission (1964-66) it is envisaged that the I.C.A.R. eventually will have within it a U.G.C. type body to advise on the development of Agricultural Education.

Financial Support for Agricultural Education

Until the later part of the Third Plan, Agricultural Education received little financial assistance from either the U.G.C. or the Ministry of Agriculture. It was only towards the mid-sixties that a definite provision was made for giving financial assistance to Agricultural Universities and colleges on an *ad-hoc* basis. After the reorganisation of I.C.A.R. and the establishment of Agricultural Education Division in the year 1966, concerted efforts have been made to develop agricultural education systematically and for this financial assistance has been provided in a planned manner.

Until 1969-70, assistance was given as per U.G.C. pattern. Accordingly, institutions which could not find the matching grant could notavail themselves of I.C.A.R. assistance and this came in the way of educational development. A revised pattern has, therefore, been adopted since 1970-71. Assistance is given under this pattern on 100 per cent basis for sixteen selected items of development of Agricultural Universities and eleven items for Agricultural/Veterinary Colleges with a ceiling of Rs. 2.0 crores for Agricultural University, Rs. 8·00 lakhs for the Post-graduate college and Rs. 4·00 lakhs for the Under-graduate College during Fourth Plan period. The total outlay for schemes of Agricultural Education is Rs. 28·00 crores during Fourth Plan period. This support is in addition to the central support that these institutions receive for participation on various research and development schemes and to the State support that they get in respect of committed and for development expenditure.

Current Schemes of Agricultural Education

The following schemes of Agricultural Education are in operation during the Fourth Plan period:

1. Establishment and development of Agril. Universities.
2. Development of Agril./Vety./Dairy Science Colleges.
3. Improvement of Agri. Colleges of Central Universities.
4. Award of scholarships and followships to undergraduate and post-graduate students of agriculture.
5. Establishment of centres of excellence.
6. Organisation of Summer Institutes.
7. Improvement of Teaching Faculties competence.
8. Higher Education in Food and Nutrition at Agril. Universities/Colleges in India.

Details regarding the first 3 schemes have already been given in the foregoing pages.

Scholarships and Fellowships

To start with, the Junior and Senior Fellowships of the value of Rs 150 and Rs. 200 p.m. respectively were offered. At present, I.C.A.R. offers following scholarships and fellowships:

	No.	*Value*
1. Science Talent Search scholarships	25	Same as scheme of NCERT, of Education Ministry.
2. Merit cum-means scholarships for under graduate students.	7·5% coverage	Rs 100 p.m.
3. Junior fellowships for post-graduate students at Master's level.	335	Rs 200 p.m.
4. Senior fellowships for post-graduate students at Ph.D. level.	155	Rs 300-contingencies.
6. Senior fellowship for P.G. students at Ph.D. level for joint training participants	20	Rs 400 ,,
6. Post-doctoral fellowships	24	Rs 500 ,,

In addition, the 'Jawaharlal Nehru Awards' scheme for outstanding research work done by post-graduate students has also been recently approved. The scheme provides for 5 awards per year of the value of Rs 5,000 each.

Improvement of Quality of Education and Teachers' Training Programmes

I.C.A.R. has been helping Agricultural Universities and colleges by arranging advanced training to Faculty members in reputed institutions. The scheme of summer institute is run to bring the teachers and research workers up to date with the latest advancements in the area of their specialisation. A scheme for the establishment of 'centres of excellence' has also been initiated recently with a view to reduce dependence for advance training of teachers in foreign countries. We have been sending in the past a large number of teachers for advance training abroad with a view to improving the quality of education as quickly as possible.

Time and again the need has been felt to revise the course contents and curricula to make agricultural graduates more 'employable' and to develop in them the necessary competence and confidence for self-employment. I.C.A.R. has been organising teaching Methods Seminar where educational reforms and improvements in teaching methods, evaluation system and curricula structure etc. are discussed. It is intended to give more concerted attention to this aspect in future programmes.

Realising the need for linking enrolment and output of agricultural institutions with job opportunities, it has been decided to have a Man-power Planning and Placement Cell at the I.C.A.R., in addition to similar units at the Agricultural Universities. Similarly, a Cell for Planning and Evaluation on Agricultural Universities is considered necessary. Another scheme for utilising the internal competence already created within the country has been developed. When implemented, the scheme would help to reduce our dependence on foreign experts.

The Agricultural Universities are becoming increasingly aware of the need to start some of the new programmes on higher education such as Food Technology, Human Nutrition, Communications, Water Technology and Fisheries. It is intended to support such new programmes in future.

The key note in the development of agricultural education in years to come will be the improvement of standards and quality of education. Programmes relating to consolidation of post-graduate education, introduction of 3 year Degree course after 12 years' of schooling, orientation of curricula and courses to suit the needs of agricultural development will receive special attention. Inter-institutional collaboration in programmes of agricultural education will be encouraged particularly between Agricultural Universities and Central Research Institutes. International co-operation in the field of agricultural education would also be fostered. Special effort would be made to link enrolment to colleges with employment opportunities. Experience gained in institution-building and expertise available within the country will be utilised for the development of new institutions with a view to reducing dependence on foreign technical assistance. Planning and assessment of progress of Agricultural Universities and colleges would receive more attention in future than it has received hitherto. Programmes of students welfare and teachers' training would be particularly promoted.

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Agricultural Education Corrects Earlier Isolation of Education from Society and Economy

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THE importance attached by Free India to education is reflected in the Government of India resolution of November 4, 1948, setting up the Indian University Education Commission with Dr S. Radhakrishnan as the Chairman. The Commission's report in three volumes was published in August 1949. Monumental as this report was, its recommendations helped greatly to shape the destinies of higher education in India.

The Commission recorded deep general awareness of the importance of higher education for national welfare, uneasy sense of inadequacy of the prevailing pattern, serious shortcomings in the functioning of the universities, marked deterioration of standards in teaching and examinations, and increasing dissatisfaction with the conduct of university administration and elections of university authorities.

Pre-Independence Educational Features

By the time the Commission began to work, India had over 20 universities. All these suffered from a major defect, namely the relative isolation from Indian society and economy. Public service concept was not one of their integral features. While teaching remained as the principal activity of colleges, the universities were content in awarding degrees on the basis of examinations conducted by them. Research, which stimulates teaching, was a function of other agencies, except for what passed as post-graduate research but this too was a feature of only a few centres. In nothing perhaps were the universities more complacent and conservative than in their attachment to external examination, which was conducted by examiners chosen from institutions unconnected with teaching of the examinees, and on whose reports the students were labelled as first, second, third or lesser class intellects. Doubts have therefore been expressed as to the validity, objectivity, educational value and psychological effects of such examinations upon candidates.

The Commission bemoaned the lack of a reasonable amount of research of quality. Citing the Scientific Manpower Committee, it states that the number of Ph.D. and D.Sc. degrees in six basic sciences, awarded by the universities of India during 1938-1948 totalled to only 260, an average of 26 per year. On top of this, there were signs of a steady decline in the quality and quantity of research. Since science is indispensable to civilised existence and a main factor in determing the direction of progress, the Commission urged that the country needed a constant flow not only of trained scientific workers but also of scientific leaders imbued with the spirit of research.

The developments during the half century preceding the work of this Commission led to the establishment of 21 institutions for higher education in agriculture. The number of enrolments to 17 agricultural colleges rose steadily from 30 in 1924 to 1448 in 1948. The number of M.Sc. and Doctorates turned out from these colleges during 1946-47 was 74, while 156 candidates received post-graduate diplomas in agriculture, veterinary, forestry, dairying and allied sciences in the same year. Facilities for training in post-graduate research work in agricultural sciences were available in India in 1948 for only 166 students. The Commission compared this situation in India with that in the U.S. where there was no agricultural education prior to 1862. After July 1862, when the Morrill Act was passed as many as 70 land grant universities and colleges were established until 1949, enrolling approximately a million students, besides reaching a large section of the adult population through extension educational services. As an indication of how fast the economic structure in the U.S. was being developed, the Commission has pointed out that "the total agricultural income of Florida was $97,980,000 in 1935, $115,009,000 in 1940 and $413,071,000 in 1946".

University Education Commission's Recommendations

For Rural Universities the Commission devoted one whole chapter. The Commission specifically recommended that "a rural university should include a ring of small, resident, undergraduate colleges, with specialised and university facilities at the centre." A common core of liberal education was recommended for the rural university as for other universities, though the methods used in teaching and learning may be different. This common core should include substantial introduction to the fields of mathematics, chemistry, physics, geology, biology, physical education, psychology, the social sciences, philosophy, language and literature. As to advanced and specialised subjects, the Commission recommended that no field of human concern should be foreign to the rural university. The curriculum should be made to fit into the needs of individuals, and not the students made to conform to an arbitrary curriculum.

Rural Institutes

While no action was taken to implement the recommendation of the Royal Commission on Agriculture to set up Rural Universities, the Government of India in the Ministry of Education set up a Committee in 1955, which recommended the establishment of a number of so-called "Rural Institutes". Little attention was paid to the pattern proposed by the Commission for the formation of Rural Universities. The term "Rural Institutes" for an analogous institution with a different series of objectives was adopted. The rural institutes have, however, had a chequered career, neither becoming popular with the public, nor developing a capacity to render effective service, so that they never counted as centres of higher or vocational education in agricultural sciences.

Distinguishing Features of Agricultural Universities

In adapting the pattern of the land grant college the Agricultural Universities in India, the first of which was started more or less as an experimental measure late in 1960, but which now total to 20 in number, have taken certain measures to distinguish them from the traditional ones. In the words of Cummings Committee these distinguishing features are the following:

(1) The Agricultural University recognises a responsibility and responsiveness to the needs of cultivators in contrast with being only a seat of learning and scholarship, and assumes a responsibility for working towards the economic development and improvement of the standard of living of the people of the State.

(2) In addition to resident teaching for degree candidates, the staff also have responsibility for applied as well as fundamental research in agriculture. Such research must go beyond the laboratory and into the fields and home, and with the livestock, under varying conditions found in different parts of the State.

(3) The Chief medium through which the cultivators are to derive the benefits of the training programmes and of the research work under agricultural university is the extension limb of the university, which should be fully integrated with teaching and research organisations, so that a smooth and effective flow of the results of research and of the training programmes to the cultivators be possible and the problems of the cultivators may similarly be transmitted back to the teaching and training centres for being tackled promptly and effectively.

(4) The territory of the university with respect to the agricultural and related sciences should include the entire State, in keeping with the above principles and responsibilities.

(5) The curricula and the training programmes should be modelled in a manner as to be in keeping with the needs of the State on the one hand, and of the aptitudes and needs of the individual students or trainees on the other. This must involve the formulation of a flexible curriculum with suitable provisions for courses of instruction in a wide field and the appointment of teachers who have specialised in their respective disciplines.

The abandonment of the old curriculum with its external examinations and its replacement by a more complex curriculum with internal evaluation is perhaps the most important single consequence of the reform as reflected in the introduction of agricultural university concept in the post-independence era. This is of special significance in the context of immense pressure for superficial education in the pre-independence period; something to give reputation and polish at the least expense of time and effort. One becomes "an educated man" by virtue of getting a parchment in a convocation; this was the oft-repeated allegation, but which cannot apply to the reformed institutions under the current agricultural university set-up.

Innovations Introduced

When the trimester system was introduced in these universities the teachers who brought many prejudices and preformance derived from their previous training and from their personal idiosyncrasies found it difficult in the beginning to adjust themselves to the new system of teaching and examination. Some had been teachers for long under the old system; some had been trained under the Indian and English Universities where semester or trimester systems were not followed. The free and frank discussions during the orientation helped to remove misunderstandings. Fortunately, many teachers had a model to be followed, a model in which nearly half the teachers of the rank of Assistant Professors and above in at least some universities had already experience in the U.S. institutions through the participant programme.

Each course in a semester or trimester is self-contained and complete. Final marks are given for each course upon the termination of study and examination in that course. The earning of a degree by a student is determined by the cumulative marks in the individual courses.

Students may elect to establish a major in any one of the divisions of the university other than the division of basic sciences. It is the purpose of the curriculum to provide that all students have a fundamental understanding of the State's agriculture and the underlying basic sciences.

The curricular changes introduced by the agricultural universities since their inception together with an appreciable improvement in the attitudes of the teachers, in course content, and teaching methods have greatly upgraded the standard of teaching agricultural sciences. There is an awareness among these universities to encourage coverage of many different fields in an integrated or cohesive manner. The provision for a good deal of flexibility of curriculum permits deep penetration into a selected field of knowledge and leads to some degree of specialisation at the undergraduate level. A certain degree of diversity in individual training has thus been introduced enabling students to acquire special competence in the fields of their greatest interest and capability. In a field which presents technical and practical problems such as in agriculture, training all students exactly the same way as in traditional type colleges will not help the country to deal with all problems resourcefully.

The external examination which has merited strong condemnation by the University Education Commission as one of the worst features of Indian educational system has been completely eliminated by most of the agricultural universities, while some have been able to do this in part. A few universities having both the affiliated and constituent colleges, have introduced internal evaluation only in their constituent colleges of agricultural sciences. In some universities with a large number of campuses, the maintenance of uniformity in evaluation standards presents a problem of some magnitude, but each of these universities has been endeavouring to devise solutions to it. Until a system of accreditation is adopted by each institution or by the Association of Agricultural Universities to maintain high standards, this problem is likely to continue.

The content of examinations has also been modified in several universities in order to better measure the specific kinds of student competence and to serve as effective aids in the teaching process.

Internal examinations make for more effective overall student-teacher relationships, permit adaptation of courses to local situations and problems, to new knowledge and to particular competencies and interests of students and instructors, thus making courses much more challenging both for students and instructors and developing an enquiring attitude towards the subject-matter.

Advantages of intermittent examinations, and other devices, for measuring student performance over the erstwhile terminal or annual examinations are: (a) they encourage constant study throughout the year and thus develop in students good work habits, (b) they greatly improve overall classroom performance by keeping students abreast of subject matter, (c) they permit the instructor to appraise his teaching and to make necessary modification, and (d) they permit use of examinations as effective teaching aids. Intermittent examinations are supplemented by a final examination which covers the course as a whole and contributes about one-third of the students' total marks.

Research and Extension

Research in agricultural sciences, though is integrated with education and extension under the agricultural university concept, is currently the responsibility of the Centre, State Governments and Agricultural Universities. Some of these universities enjoy State-wide responsibilities, while others have yet to acquire this status. Even in the former case there is some division of responsibilities between the University and the Central Institutes, who number about 23 with over 100 sub-stations sprawled all over the country. Through about 100 All-India coordinated research projects and some *ad hoc* research projects financed by the ICAR and other agencies as well as the Universities' own resources, the Agricultural Universities have played an important role, contributing to the progressive improvement of all the vocations falling within the purview of agricultural sciences in India, even though the ICAR continues to be responsible for the largest segment of research in the country.

Much has been written and said about extension services developed in India in the post-independence era through National Extension Services, Community Development Programmes and Panchayat Raj institutions. At the State level the extension responsibilities are not clearly demarcated between the various agencies. However, the agricultural universities have departments of extension for imparting extension training a swell as for disseminating results of research to the cultivators. Some of these universities have gone further in supplementing and complementing the efforts of State Departments as a prelude to the eventual taking over the State-wide extension education responsibilities. They have also been assisting the State Departments by conducting several types of training programmes to upgrade the skills of their extension workers. These developments are in harmony with the Education Commission's recommendation that extension work which provides the necessary link between new elements of technology developed through research and application to farm practice should be entrusted to agricultural universities, through a phased programme, as staff and other resources permit, while the supply services should be separated from extension work and entrusted to State Departments.

Development of Agricultural Universities

The Development of Agricultural Universities could not be expected to proceed on any rigid pattern. Subject to the administrative policies and procedures prevailing in each State, the development has necessarily to be on dissimilar lines, even though the goals remain the same. In fact, no two agricultural universities in India were conceived, established or operated on a standardised pattern. Such a dissimilarity is indeed an advantage so long as the basic concept, philosophy and objectives are not compromised, for the diverse experiences gained by the adoption of different approaches and procedures could convey valuable lessons to the future.

Although the Indian Agricultural Research Institute was established over 100 years ago, it is deemed as an agricultural university now, since it has a large post-graduate programme in agriculture, besides having the responsibility for the conduct of research in a vast and comprehensive field and for extension educational work in the Union territory of Delhi.

Although all these universities possess the freedom to innovate, their efforts have not followed a rigid pattern. The label of an agricultural university does not therefore connote the nature and extent of innovations made or the value thereof. Energetic and forward-looking leadership with motiavation and capability for initiating and seeing through the innovative process may not be avaiable in all cases. It is not therefore surprising if a few of the universities remain virtually indistinguishable from the traditional universities. The problems of transition and adjustment to their new status and responsibilities, which may partly be their own creations, become rather formidable in such cases.

As the ICAR has recently pointed out "The year 1970-71 will go down in the history of India as golden year in which the country achieved self-sufficiency in food and wiped off the quarter century old stigma of going round the world with a begging bowl for our daily bread." In this unique accomplishment the Agricultural Universities and the Central Institutes under the coordination of the ICAR have played a worthy and significant part.

Looking back with hindsight an observer might say that these new universities have suffered from several handicaps and have also made some mistakes. Nevertheless, they have earned their place in the history of agricultural education in India. Indeed they will always be remembered as a turning point in the history of Indian higher education. A major shake-up of university education was needed in India, and the injection of new concepts and methods through these new institutions has resulted in a shake-up of the Indian higher education in agricultural sciences out of its complacent, routine and insular ways of operation.

The resourcefulness displayed under severe stress by some of these universities, especially when the financial parameters were determined at times by others with no idea or understanding of the actual needs, was most noteworthy. This does not mean that there were not considerable variations in the care and efforts bestowed on planning and budgetary estimating. The outlook, energy, dynamism, capabilities and other forward-looking qualities of the founding fathers of these universities and more especially the personality of the Vice-Chancellors during the formative years had much to do in shaping these universities and setting the pace of progress.

The contributions made by these universities were not only in experimenting in many academic directions such as in curricula, methods of teaching and assessment, new structures of organisation, and in forms of physical development designed for growth, but also in promoting smooth relationship with staff, faculties and students, in research and community service which have gained new strength, acquired new dimensions and new meaning and higher capabilities, which are all reflected in tangible contributions. In the field of governance some daring experiments have been made, although most institutions have remained content with conventional methods. In many ways indeed the old tradition has been broken, though it is too soon to judge just how much of all these developments have given a "shake-up" to the rest of the Indian University system.

Education of the Farmers and at Lower Levels

Education for agriculture is intended basically to transform the life in the villages from one of feudal backwardness into that of modernised communities and to facilitate the widespread application of science and technology to the problems of agricultural production and rural betterment. This goal has been spelled out and amplified in the Report of the Education Commission 1964-66. There are some 60 million farm families in India and at least 85% of them are functionally illiterate. Upgrading the vocational skills of the rural population of this size and of educating them in modern technology is a problem of unprecedented magnitude.

The Commission has recommended that some orientation to agriculture should form an important part of all general education to make every citizen be aware of the problem of agriculture and rural life, and acquire some appreciation of the skills needed in farming, and of the new horizons and possibilities opened up by science and technology. This, says the Commission, will lead to better realisation by policy makers of importance of the well-being of the primary producer for the improvement of agriculture and the general economic betterment of the nation. Among its specific recommendations are:

(i) to give an agricultural orientation to the programmes in primary schools, and

(ii) to make agriculture on important part of work experience and an essential component of a national system of education in lower and higher secondary stages.

All these require trained teachers who can advantageously and cheaply be produced in agricultural polytechnics attached to Agricultural Universities.

We are spending currently a great deal and a very disproportionate amount on undergraduate and postgraduate education, but little on farmers' education to train and to make over 60 million farmers' families, and over 220 million people below the poverty line in the country to make them vocationally skilled or self-reliant and be self-employed in modernised agricultural or allied rural vocations.

With the imposition of land ceilings, the disposal or assignment of surplus lands would soon become an important problem. According to the Vice-Chancellor of Haryana Agricultural University, there is bound to be a scramble by all kinds of people for these lands. They may be genuine or bogus cultivators. A large number may have no background of cultivation or even inclination to be tillers of the soil. This scramble, if allowed to succeed, may lead to gradual alienation of land on one side and declining productivity on the other.

The present time is therefore opportune for undertaking certain measures which will not only maintain the productivity but also help in rapidly modernising our agriculture. Furthermore, these measures should help in reducing unemployment and underemployment and generate opportunities for the people to become self-reliant. They should also enable us to promote intensive agriculture, generating sources for ancillary income through the acquisition of skills and knowledge in many rural vocations. Equally important is the need for improving our rural education at the lower levels through the provision of properly trained and equipped teachers to give the necessary orientation to agriculture and thus disseminate widespread appreciation of the role of agriculture and rural vocations in our economy.

Neither the 2000 and odd multipurpose high schools nor the vocational schools of Manjri and other types having succeeded so far in imparting the vocational competence to the rural youth to become practising modern farmers, the Education Commission has therefore recommended the establishment of specialised institutions (Agricultural Polytechnics) on a priority basis.

Establishment of these Agricultural Polytechnics is a novel, unconventional and imaginative idea. It seeks to create an institution for which perhaps there is no parallel in this country or elsewhere, with the sole object of providig an instrument for the progressive improvement of our agriculture in every region. The overall effect of this should be to create a new hope among our rural folk and a new urge to secure the best out of our land with the aid of modern science and technology, at the same time creating self-reliance, thus reversing the current trends for exodus of our rural youth to urban areas. All these will also mean an appreciable decrease in unemployment and under-employment and an appreciable increase in the transfer of people below the poverty line, above that line. The general improvement in the institutional status of the countryside is also an integral part of the programme. The whole rural educational activities in the primary and secondary schools will be oriented to be in harmony with the general overall aims of this new project. The University of Agricultural Sciences, Bangalore has made a beginning in this direction, and the Government of India have decided to establish a few of these institutions during the Fourth Plan.

Conclusion

Educational investment would only be profitable when the products of our agricultural universities are gainfully employed. It is impossible at the present stage of our development to regulate our enrolment strictly with the requirements of graduates in private and public sectors. A certain number is bound to be available for farming on their own. In fact, the greater is this number, the more will be the utility of our colleges of agricultural sciences. In order, therefore, to make our investment on agricultural universities most profitable and to generate opportunities for gainful employment for every graduate coming out of our agricultural colleges, it is suggested that the first preference in the assignment of surplus land, after imposition of land ceiling, may be to agricultural graduates who have undergone practical training in crop production for a minimum period of one year after graduation. This post-graduate training in practical agriculture and related vocations has also proved to give the much needed self-reliance and the skill to agricultural graduates, to enable them to be most productive workers both in private and public sector.

The Education Commission report of 1966 begins with the statement that "the destiny of India is now being shaped in her class rooms". So far as education in agricultural sciences is concerned, the destiny of the country is also being shaped in her fields, animal houses, around fish ponds, and other rural establishments. On the quality and number of persons coming out of our Agricultural Universities and Agricultural Polytechnics will depend our success in the great enterprise of national reconstruction whose principal objective is to raise the standard of living of our people, with the spirit of self-reliance and social obligations inculcated in them.

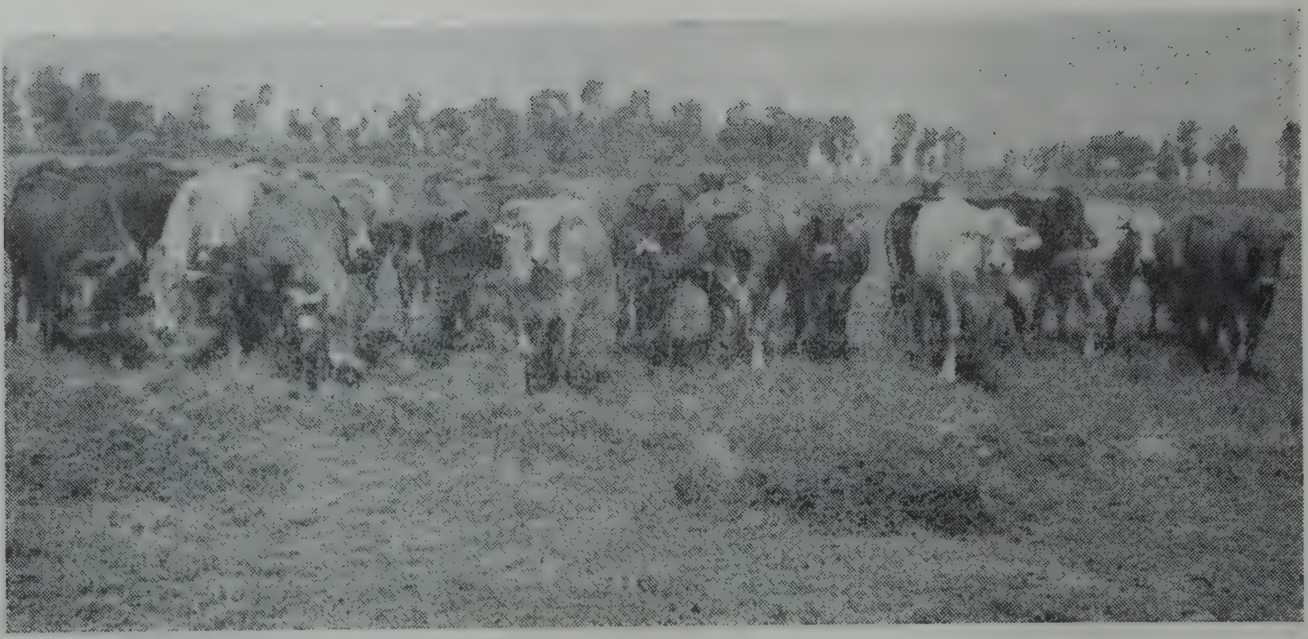


Fig. 1. A group of Karan Swiss cows

SOME ACHIEVEMENTS OF NATIONAL DAIRY RESEARCH INSTITUTE

D. SUNDARESAN
Director, National Dairy Research Institute, Karnal

THE National Dairy Research Institute has developed from the Imperial Institute of Animal Husbandry and Dairying established in Bangalore in 1923. Dr H.D. Kay, Director of the National Institute of Research in Dairying, United Kingdom, on an invitation of the Government of India, in 1946, gave a report on Dairy Research, Dairy Education and Dairy Development. The National Dairy Research Institute of Karnal is essentially an outcome of this report. In 1955, the former Imperial Institute of Animal Husbandry and Dairying subsequently changed to Indian Dairy Research Institute, became the National Dairy Research Institute. After independence it was shifted from Bangalore to Karnal leaving the Bangalore Station as the Southern Regional Station of the Institute.

In the earlier days, this Institute had done some outstanding work in quality control and in chemical and bacteriological standards for milk in addition to initiating work to develop high-yielding dairy animals for the country. Since Independence the Institute has had a record of research making an impact in the dairy industry of the country, both in production and manufacturing.

The work of the Institute clearly established that for dairying to become an industry, cost of production of milk has to be lowered to give adequate margin to the producers. Research work was directed in the field of dairy production to achieve this aim. Two major contributions to achieve this aim are:-

(i) Development of high-yielding dairy animals;

(ii) Development of fodder cropping Programmes to provide nutrients necessary for milk production in the most efficient manner.

High-Yielding Dairy Animals

As a result of early experience in the Southern Regional Station at Bangalore and work started in 1962, a new strain of Dairy Cattle 'Karan Swiss' has been developed in Karnal incorporating exotic inheritance from Brown Swiss and Zebu inheritance from Sahiwal and Red Sindhi. A nucleus herd of 140 Karan Swiss cows alongwith 187 female followers, and bulls are available for providing germplasm for increasing milk production. The Karan Swiss female calves weighed 27 kg at birth—range 16 to 41 kg. These were 25 to 30 per cent heavier than their contem-

Fig. 2. Maize-Cowpea

porary pure bred zebu. The cross-bred calves grew at a faster rate, by additional 100 grams a day, compared to the zebu. At six months of age, a cross-bred female averaged 127 kg as against 100 kg for the zebu base. The weight at first service for the Karan Swiss was 270 kg as against 247 kg for the zebu and the weight at first calving was 377 kg as against 322 kg for the zebu. The average age at first calving for the Karan Swiss was 30 months as against 40 months for the zebu. The Karan Swiss also had a better reproductive efficiency. It took 1·4 services per conception as against 1·7 in the case of zebu.

The milk production of Karan Swiss as compared to the contemporary Sahiwal cows is given in Table I. On an average Karan Swiss produced 60 per cent more milk than the Sahiwal.

High-Yielding Nutritious Fodders

Several fodder cropping programmes were tried to maximize fodder yields and increase numbers of high-yielding dairy cattle that can be maintained per hectare of land. Two programmes gave the best results.

Two crops of maize and cow pea, a third crop of maize, teosinte and cowpea, in the summer and Monsoon months followed by a fourth crop of oats and mustard yielded 150 tons of green fodder a year per hectare. At 50 kilo of green fodder of high nutritive value enumerated above per cow per day, one hectare of land has maintained 8 high-yielding dairy cows. This fodder provided most of the nutrients necessary for maintenance and milk production. Each cow needed only about 300 kgs of concentrate mixture as a supplement in a year. This high nutritive fodder feeding programme brought down the feed cost per litre of milk to 0.30 paisa.

Another similar cropping programme was developed. A mixture of jowar, bajra, sudan, teosinte and cowpea in the kharif season and a mixture of berseem, mustard and oats in the rabi season, through four cuts for each of these mixtures, yielded 200 tons of green fodder a year per hectare adequate to support 10 cows.

Economics of Milk Production

An investigation by the Economics Division of this Institute has convincingly established the relationship between the level of milk production and cost of milk production. The cost of milk production in the Sahiwal herd averaging 2000 litres of milk per lactation was Rs 1.10 per litre, whereas for the Karan Swiss herd averaging 3,000 litres of milk per lactation, it was Rs 0.72 paisa per litre. A closer study of cost of milk production of the various levels of milk production within the breeds' established that as the yields went up, the cost of milk production per litre came down. The various components that went into consideration for calculating cost of milk production area, feeding labour, supervision, miscellaneous expenditures, depreciation on livestock, depreciation on structures. The relevant figures are given in Table II.

For the same level of milk production, the cost per litre in the cross-bred is lower than that of zebu breeds. This is due to early age at first calving and shorter calving interval in the case of cross-breds than the zebu breeds.

A Demonstration unit in five hectares of land supporting 32 high yielding cows had produced in 1971-72 a net profit of Rs 24,000 averaging about Rs 800 net profit per cow.

Fig. 3. Oats-Mustard

Buffalo Milk Technology

The organized dairy industry of today depends heavily on buffalo milk. The manufacturing processes available widely, are based on cows milk. This Institute has worked on buffalo milk chemistry and technology to provide the base for developing processs for manufacturing milk products from Buffalo milk as satisfactorily as from cows milk. Sweetened condensed milk and evaported milk of satisfactory quality could not be produced from buffalo milk in view of its different chemical composition and behaviour when conventional methods of manufacturing are used. By altering the conventional methods through the use of sodium citrate as a stabiliser, flash heating at 115°C to enhance stability and to prevent subsequent gelation and

TABLE 1.
PERFORMANCE OF THE KARAN SWISS AS COMPARED TO SAHIWAL

	305 *days or less lactation yield*		*Lactation yield* (Kg)		*Lactation length* (Days)		*Calving interval* (Days)	
	Karan Swiss	*Sahiwal*	*Karan Swiss*	*Sahiwal*	*Karan Swiss*	*Sahiwal*	*Karan Swiss*	*Sahiwal*
1st Lactation	3076 (78)	1758 (82)	3407 (73)	2136 (75)	343 (73)	373(76)	405 (70)	470 (80)
2nd Lactation	3010 (61)	1789 (37)	3212 (61)	1971 (37)	310 (61)	326 (37)	386 (61)	435 (35)
3rd Lactation	3426 (57)	1710 (9)	3645 (57)	1875 (8)	303 (57)	303 (8)	387 (57)	379 (8)
4th Lactation	3519 (43)	1060 (2)	3635 (38)	1060 (2)	308 (38)	212 (2)	396 (36)	309 (1)
5th Lactation	3431 (17)	—	3631 (14)	—	309 (14)	—	388 (14)	—
Av. cumulative yield up to 2nd Lactation	6083 (59)	3681 (31)	6592 (59)	4365 (31)	662 (59)	727 (31)	786 (59)	910 (31)
Av. cumulative yield up to 3rd lactation	9513 (55)	5215 (7)	10189 (55)	5664(7)	960 (55)	956 (7)	1170 (54)	1221 (7)
Av. cumulative yield up to 4th lactation	12728 (43)	6172(2)	13390 (38)	6284 (2)	1228 (38)	1110 (2)	1554 (25)	
Av. cumulative yield up to 5th Lactation.	15077 (7)	—	15915 (14)	—	1494 (14)	—	1941(8)	

Fig. in parenthesis indicates the number of animals averaged

Fig. 4. Demonstration Dairy Unit

TABLE II

Average cost of maintenance per cow/day per calving interval and cost per litre of milk (Rs.)

Production level (Litres) per calving interval	*BREED*							
	Tharparker		*Sahiwal*		*Red Sindhi*		*Cross-bred*	
	per cow/ day	*per lit. of milk*	*per cow/ day*	*per lit. of milk*	*per cow/ day*	*per lit of milk*	*per cow/ day*	*per lit of milk*
<800	3.93	2.93	3.88	2.47	3.87	2.35	3.65	2.90
801-1200	4.54	1.76	4.24	1.77	4.24	1.62	4.02	1.40
1201-1600	4.72	1.44	4.54	1.41	4.54	1.30	4.33	1.10
1601-2000	4.91	1.27	4.82	1.18	4.76	1.11	4.66	0.95
2001-2400	5.27	1.06	5.00	1.06	5.34	0.92	5.01	0.81
2401-2800	5.58	0.96	5.32	0.96	5.53	0.80	5.30	0.74
2801-3200	5.08	1.07	5.23	0.97	5.42	0.87	5.48	0.71
3101-3600	5.35	1.01	5.31	0.92	—	—	5.78	0.66
3601-4000	5.50	0.95	—	—	—	—	5.92	0.64
>4000	—	—	5.14	0.96	—	—	5.83	0.63

GHEE
densed
MILK

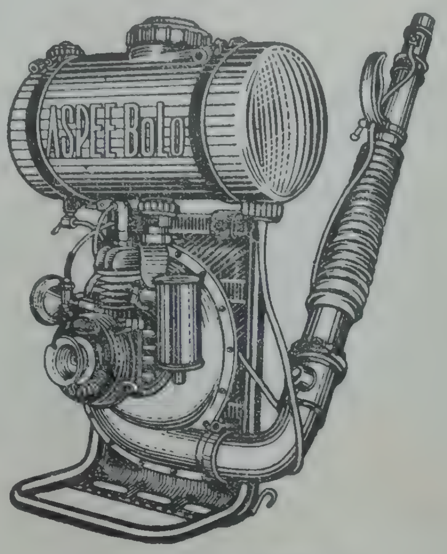
Fig. 5 Products from buffalo milk

seeding with pulverised oactose (B.P. 200 mesh) at 30-31°C and holding for 3 hours resulted in a very suitable product comparable to the best cows milk products marketed.

Another product which could have a commercial market from buffalo milk is sterilized cream. Standard methods were developed for handling buffalo milk. Preheating the cream at 75°C and homogenizing it at 150/50 kg per sq cm, use of sodium citrate at 0.2% and sodium phosphate at 0.1% as stabilisers, sterilization of the tinned product at 115-116°C for 14 or 15 minutes produced an acceptable shelf life of six months at room temperature.

Another investigation conducted was on solubility of roller dried whole and skimmed buffalo milk powder. Preheating the milk to 95°C reduced the moisture content in the final product. Loss of solubility was less for products dried at steam pressure of 80 pounds per sq in compared to steam pressure of 60 pounds per sq in. Double gas packed samples retained initial solubility to a greater degree than did the single gas packed samples.

The Institute has drawn ambitious plan for the seventies to identify the needs of tomorrow in the dairy industry and develop practices and technology to meet these needs.



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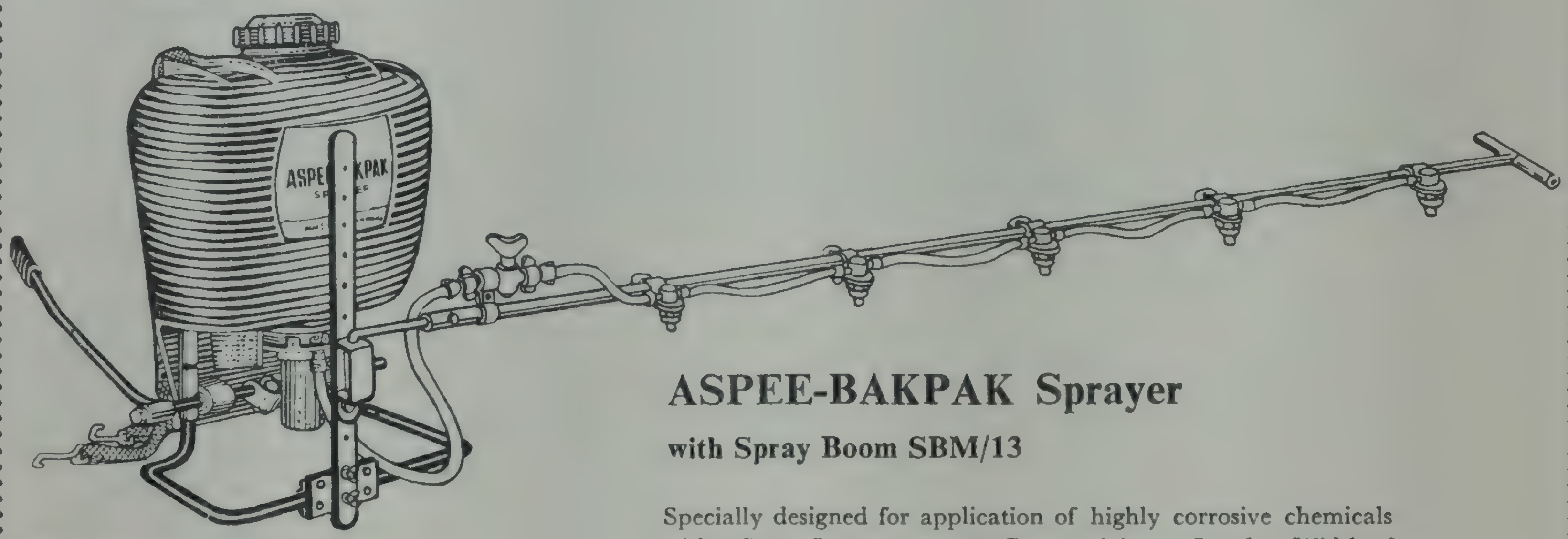

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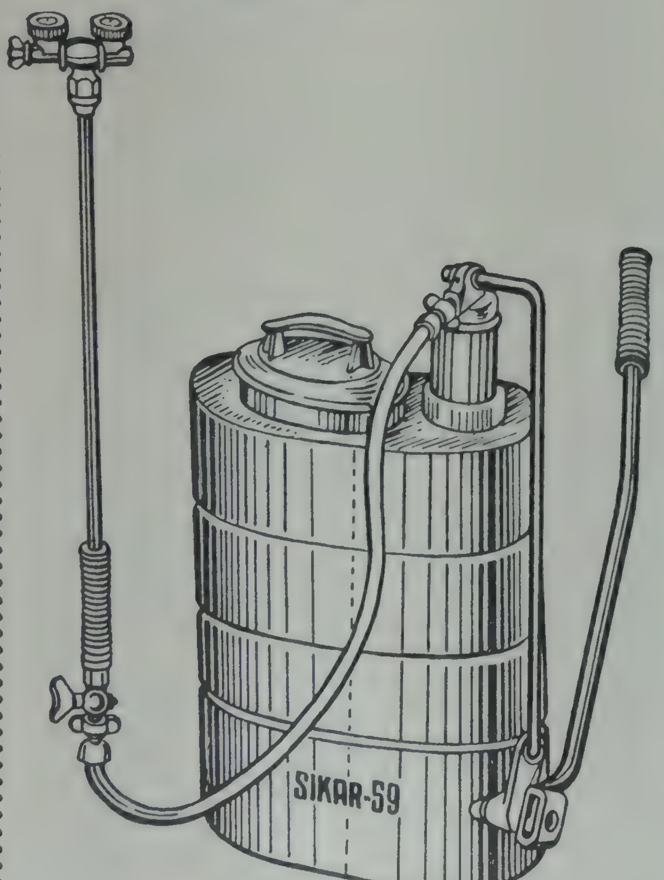

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INDIAN VETERINARY RESEARCH INSTITUTE
A Brief Survey of Achievements

C. M. SINGH
Director, Indian Veterinary Research Institute
Izatnagar (U.P.)

ORGANISED scientific research into the problems of livestock conservation and development in India started in 1889 with the establishment of what is now known as the Indian Veterinary Research Institute.

With the dawn of Independence in 1947 the Institute successfully completed 57 years of useful service by contributing significantly to the national economy through conservation of livestock health and augmenting livestock production. After Independence the name of the Institute was changed from Imperial Veterinary Research Institute to Indian Veterinary Research Institute with an Indian scientist as its Director. With the re-organisation of the Indian Council of Agricultural Research, the IVRI among other central institutes was brought under the administrative control of the Council in 1966. Since then emphasis has been on problem-oriented research with multidisciplinary approach towards augmenting livestock health, production and technology.

Achievements

Livestock Health. The Institute has made significant contributions in conservation of livestock health. Large scale production of tissue culture vaccines against foot-and-mouth disease and rinderpest have considerably reduced economic losses accruing due to morbidity and mortality. The production of these vaccines is being augmented for protection of valuable exotic, cross-bred and high producing livestock in the country. Work is in progress in evolving an efficacious vaccine against sheep-pox. In combating bacterial diseases, efficacious vaccines have been developed against anthrax, black-quarter, black disease, enterotoxaemia, haemorrhagic septicaemia, etc. Simultaneously researches are in progress to determine the prevalence and distribution of brucellosis, leptospirosis, tuberculosis, etc. which besides causing recurring losses are of zoonotic importance.

Ranikhet disease of poultry is well under control. African Horse Sickness, which made its appearance in 1960, took a heavy toll of equine population. Prompt research resulted in developing an efficacious vaccine against this disease by incorporating into it the local strain of the virus. The disease has not recurred since then.

Recent research on Marek's disease—an important disease of poultry—has resulted in the development of a fluorescent antigen for quick diagnosis of the disease. Investigations have also been intensified on certain new diseases of poultry, hitherto unreported in this country. Studies have been undertaken on transmissible tumours of animals by growing cells and tumour tissue explants under artificial conditions in the laboratory. Other researches include the use of animal models to simulate certain spontaneous arterial diseases of man, and investigations on several deficiency diseases of animals. Disease investigation and laboratory diagnostic services of livestock and poultry have been reorganised and strengthened.

Conservation of livestock health depends on availability of biological products both qualitatively and quantitatively. The Institute has made significant contributions by meeting the demands of the country by supplying biological products of proven standards.

Helminthic, protozoan and arthropod-borne diseases of livestock are responsible for serious economic losses. The research work envisages systematic study of morphology, biology, ecology, diagnosis and treatment of such diseases. Work on schistosomiasis won the Rafi Ahmed Kidwai Memorial Prize for two scientists of this Institute. Investigations on the incidence and prevalence of helminthic diseases in certain selected areas revealed the prevalence to be as high as 72 per cent. The more common diseases are fascioliasis, amphistomiasis, schistosomiasis, strongylosis, ascariasis and trichuriasis. Numerous anthelmintic drugs have been evaluated for their efficacy against different parasites. Studies have been conducted on biology of various helminths. An aquatic snail has been found to be the intermediate host of intestinal fluke of man and pigs. A dipterous fly was incriminated as vector of causative parasite of humpsore in cattle. A species of mosquito was found to be vector of filariid worm of buffaloes. Two species of ants were found to be the intermediate hosts of certain tapeworms of pigeons. Further researches on bearing of nutrition on parasitic burden, investigations on the incidence and distribution of ticks, screening of certain chemosterilants and development of resistance in ticks have given encouraging results. Certain arsenicals, antimonials, diamidines and other compounds were tested and evaluated for their level of activity against trypanosomiasis, Infection of poultry with *Eimeria necatrix* has been recorded for the first time in the country. Evaluation trials of a number of coccidiostats showed that sodium salts of sulphamethazine and nitrofurazone suppressed mortality in chicks due to *E. tenella* infection.

Under the UNDP/SF Project on Nuclear Research in Agriculture an irradiated vaccine has been developed against lungworm of sheep. The first trial with this vaccine was conducted in 1970. Based on clinical and parasitological data, the vaccine was found to be highly effective in reducing the overall incidence and intensity of infection in the state. The second trial was conducted in Kashmir in 1971. In the first trial 2000 sheep were vaccinated and in the second trial the vaccine was given to only those animals which had received the first dose. In view of the encouraging results further trials are contemplated in Himachal Pradesh.

Livestock Production

Milk Production. The livestock population in India is very large. But the lacuna between requirements and availability is largely due to low productivity of our livestock. Studies with indigenous breeds have indicated that quicker results in the improvement of milk production, reduction in age at maturity and improvement in breeding efficiency can be achieved by cross-breeding with exotic dairy breeds. To bridge this gap an All-India Coordinated Research Project on Cross-Breeding of Cattle has been sanctioned and is in operation at this Institute. The IVRI is also the coordinating agency for the other research centres in various parts of the country. The research programme under this project would be pursued according to the recommendations of workshops already held and to be held in future. With buffaloes the work will primarily be on the selection and other aspects of research such as physiology, nutrition, reproduction, etc.

Mutton Production. Sheep contribute approximately to one-fiftieth of the total production of meat from all species of livestock. Sheep mutton is acceptable to a large proportion of the population and there is greater scope to increase its production. An All-India Coordinated Research Project on Sheep for Mutton has been sanctioned for operation at this Institute. The ultimate aim is to evolve new breeds of sheep by cross-breeding well suited to different climatic conditions and capable of yielding more meat for human consumption.

Pork Production. Pigs are prolific breeders and efficient converters of waste food and garbage. It provides nutritious food for a sizeable population of the country. An All-India Coordinated Research Project on pigs has been sanctioned at this Institute as the coordinating agency. The aim is the formation of inbred lines, their tests for maximum general and specific combining ability and eventual production of hybrid pigs suitable for our conditions.

Egg Production. The importance of eggs as a source of food for human consumption is well known. High-yielding strains of poultry by importation involve huge amount of foreign exchange. To dispense with this dependence it is high time to develop the strains within the country for increased production. It is also highly desirable to preserve the indigenous germ plasm for future exploitation. An All-India Coordinated Research Project on Poultry for eggs has been sanctioned and is functioning at this Institute. The objective is to evolve high egg producing strains of poultry by crossing the best available germ plasm and developing inbred lines from such a stock for future crossing programme.

Poultry for meat production. Poultry farming which used to be considered as a backyard farming has now been receiving greater attention. A number of organised Government and private poultry farms have been established. In spite of these expansions, the production of poultry meat has been rather low. The All-India Coordinated Research Project on Poultry for Meat which is in operation at this Institute aims at evolving a broiler strain gaining adequate weight at a comparatively small age by crossing of inbred strains of common broiler breeds.

Mohair Production. Goats besides being a source of mutton have the potentiality of producing fine lustrous fibre e.g. Angora and Pashmina breeds. An All-India Coordinated Research Project on Goats for Mohair Production has been sanctioned at this Institute. It is envisaged to evolve new breeds of goats capable of yielding fine mohair and pashmina by cross-breeding.

Laboratory Animal Production. In view of intensification of research activities in the multifaceted aspects of veterinary science and animal husbandry, adequate supply of standard type of laboratory animals cannot be ignored. Supply of experimental animals properly bred and reared under controlled conditions must be ensured. This problem is important not only in India but also in the countries of S.E.A. region. Care, handling, breeding, etc. of laboratory animals were given special attention in the International Seminar on Health Laboratory Services organised by the WHO in 1960 at Manila along with a bibliography of Animal Breeding, Care and Management. In many foreign countries this aspect has been receiving prior attention.

In India realising the importance of the desired type of experimental animals for research, the WHO Regional Office for S.E. Asia Region has played a significant role in undertaking an assignment on this problems. The WHO in 1965 undertook a study of the status of experimental animal management in various places in India and to advise the Government and institutes on the production of animals for purposes of research, diagnosis and vaccine testing.

Keeping in view the importance of desired type of laboratory animals, a proposal for the establishment of a National Laboratory Animal House at the IVRI has been made. This proposal has the support of three major research organizations in the country, viz. I.C.M.R., C.S.I.R. and the I.C.A.R.

Ruminant Digestion and Metabolism. In view of the shortage of the concentrates for feeding animals, the attributes of the ruminants for utilization of food otherwise unfit for human consumption and through integrated approach in exploiting these ruminants from different angles by research such as rumen physiology, rumen microbiology, carbohydrate, protein, mineral, lipid and NDN metabolism, energy metabolism, endocrinology, use of radio-isotopes and feed processing have to be undertaken through integrated disciplines. The research projects should be oriented to understand the optimum environment in the rumen for efficient utilization of nutrients.

Under the UNDP/SF of I.A.E.A. a Nuclear Research Laboratory has been set up at this Institute for conducting research on the above aspects.

In order to ensure adequate supply of standard feeds and fodders for our livestock research, programmes have to be directed towards nutritional requirements of exotic and cross-breed cattle, comparative efficiency of conversion of feeds into milk by use of radioisotopes, development of pilot feed processing plant, better utilization of agro-industrial by-products, distribution and metabolism of trace elements and swine, sheep and goat nutrition etc.

Adequate and incessant supply of quality fodders is an essential part of the above activities. It must, therefore, be ensured that quality fodders and forages are always available. This can be achieved by adopting multi-cropping, inter-cropping and high altitude forage production programmes.

Animal Reproduction. To overcome the reproductive inefficiency of our livestock, poultry and buffaloes, an integrated multi-disciplinary approach has to be adopted to solve this problem.

The unsatisfactory state of sexual maturity and fertility of farm animals in India need to be improved. A detailed and systematic study of the various genetic and non-genetic factors which affect fertility of farm animals has to be carried out. Therefore, studies have to be directed towards animal genetics, artificial insemination including frozen semen, physiopathology of reproduction and other reproductive disorders, nutritional, parasitological and other microbiological disorders. The contributions thus made would have a greater impact in increasing the productivity of the animals in view of intensive cattle development programmes throughout the country.

Livestock Technology

Feed Technology. It has been very well realised that the research contribution would not be of much avail unless pilot projects for the processing of the innovations developed are carried out in the research institutions before large scale processing is undertaken industrially. It has, therefore, been envisaged to set up a pilot project unit of feed technology for not only formulating quality nutrients but also for developing methodology for the processing of feeds in a suitable manner.

Poultry and poultry products technology. Marketing of poultry products in a suitable form is vital for the cause of the poultry industry in India. Work, therefore, has to be taken up on processing and preservation of poultry products with special emphasis on curing of chicken meat, standardization of conditions for manufacturing egg powder, frozen egg pulp and other convenient food items containing egg and egg products. In these activities it will be important to ensure that the product reaches the consumer in the acceptable form besides providing incentive to the producer.

Livestock Products Technology. In view of the urgency of not only processing of meat and meat products but also the slaughter house by-products steps have already been undertaken to carry out research activities in this direction.

A Division of Livestock Products Technology has been sanctioned for establishment at this Institute during the 4th Plan. The work will be conducted on multifaceted aspects of technology with the aim of maximum beneficial utilization of livestock products and slaughter house by-products.

As a result of expanding research activities, a number of animal carcasses would become available for disposal. A carcass utilization centre has been established to make best use of the animal carcasses by providing meat-meal, bone-meal and blood meal etc.

Veterinary Public Health. Epizootics of animals have been causing heavy economic losses from times immemorial. However, in recent times, man has realised the gravity that he too is susceptible to a number of animal diseases which are communicable to man and vice versa. Over 100 of the diseases in various parts of the world come under WHO definition of zoonoses. Notable among them are: tuberculosis, rabies, plague, typhus, brucellosis, listeriosis, leptospirosis, salmonellosis, virboisis, trichomoniasis, toxoplasmosis, tick paralysis etc. Greater attention has to be paid to zoonotic diseases particularly in the field of virology due to inter-relationship of human and animal viruses, e.g. adenoviruses, arthropod borne viruses and enteroviruses, etc.

There are a number of physical, chemical and biological agents which are associated with respiratory diseases of man and animals, e.g. myxoviruses, picorna viruses, reoviruses, herpesviruses, psittacosis, ornithosis, rickettsia, mycoplasma, bacteria, fungi, air pollution, allergins and other respiratory syndromes.

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Newer aspects of food hygiene and food control are emerging due to the residues of antibiotics, herbicides, pesticides, radioactive material and other biolgogical compounds, toxic products, etc. Importance of antibiotic strains and transfer of R-factors is well realised due to indiscriminate use of antibiotics in the animal feeds. The importance of hygienic conditions of slaughter houses and management for conducting ante-mortem and post-mortem examinations needs no emphasis.

Importance of rural health needs no emphasis in view of the fact that about 80% of rural population of man and animals in India has the intimate contact with each other under the existing living conditions. Therefore, the chances of diseases communicable from animals to man and vice versa which number over 100, are much greater in this country than probably anywhere else in the world. This point has been very much recognised all over the world. In pursuance of the resolution of the socio-economic importance of zoonoses adopted unanimously in 1969 by the 21st World Health Assembly, the first W.H.O. Regional Seminar on Veterinary Public Health for countries of S.E. Asia Region was organised at the IVRI, Mukteswar in April 1970. Consequently, a Master's course in Veterinary Public Health has been initiated at the All-India Institute of Hygiene and Public Health, Calcutta in collaboration with the IVRI. This would make available the trained personnel to man the Division of Veterinary Public Health at the IVRI besides other such units in the country. The Division of Veterinary Public Health at the IVRI envisages research activities for comparative bio-medical studies and zoonoses, meat, meat products and sea-food hygiene, milk, milk products, food hygiene and food microbiology and public health besides the strengthening of post post-graduate education.

Education, Training and Extension

Since its inception the Institute has been imparting post-graduate education in addition to its regular research activities. It is a recognised centre for post-graduate education in veterinary science and animal husbandry by a number of Indian Universities. The facilities for research and training have been so immense that as far back as 1937 officers obtained D.Sc., Ph.D., M.Sc./M.Sc. (Vet.) degrees. A post-graduate course leading to the award of Diploma of Associateship of IVRI was instituted in 1943. This is considered by the Government of India as a higher qualification for recruitment to higher posts.

With the establishment of the Post-Graduate College of Animal Sciences in 1958 the training programme was further strengthened and re-oriented so as to meet the demands of the states for suitably trained personnel. Post-graduate education and training leading to the award of post-graduate degrees is being imparted in the subjects of Pathology, Bacteriology and Virology, Parasitology, Animal Nutrition, Animal Genetics, Physiology, Biochemistry, Pharmacology and Gynaecology. Under the UNDP SF programme for strengthening of post-graduate education and research with a view to creating centres of excellence, a Master's programme in Poultry Science has been introduced from 1970. On the recommendation of the WHO and the Government of India, a Master's course in Veterinary Public Health has been instituted from 1960 in collaboration with All India Institute of Hygiene and Public Health, Calcutta. During the 4th Five Year Plan additional post-graduate degree courses viz. (1) Epidemiology, (2) Livestock Products Technology, (3) Experimental Medicine, (4) Experimental Surgery, and (5) Preventive Veterinary Medicine will be instituted.

It is contemplated to create more facilities by creating Centres of Excellence for post-graduate education and training.

So far the out-turn of post-graduates and post-doctorates has been 5 D.Sc., 70 Ph.D. and 334 Master's degrees. Forty-three officers have obtained Associateship of IVRI and about 3000 post-graduate scholars attended various diploma courses.

The facilities for post-graduate education and research have been so immense that the Institute has attracted post-graduate scholars from foreign countries such as Afghanistan, Ceylon, Germany, Hungary, Japan, Nepal, Nigeria, Philippines, Sudan, Syria, Thailand, Uganda, United Kingdom, USSR under various international programmes such as Colombo Plan, FAO Fellowships, Commonwealth Scholarships Scheme, Indo-Hungarian Cultural Exchange Programme, etc. So far 30 foreign scholars have visited this Institute for post-graduate studies.

In carrying out planned education and training programmes in the laboratories of this Institute having modern and uptodate equipments and facilities, all possible steps are taken to maintain a high standard while intensifying these programmes. The prime aim is to meet the requirements of trained personnel of not only of the country but also to provide facilities for training and research to scholars from abroad who are desirous of conducting research under tropical conditions, like India.

Besides strengthening post-graduate education and training programmes for doctorate, master's and diploma courses, short term training courses, staff courses and training of ancillary staff will be given adequate attention keeping in view the demands of research Institutes in the states and the centre.

With the expansion of research, education and training activities at the Institute, the logical consequence would be to bring the results of researches to the knowledge of the farmers and livestock owners. And in turn, to bring back their problems for an effective solution. For this purpose a Division of Extension has been established at this Institute recently.

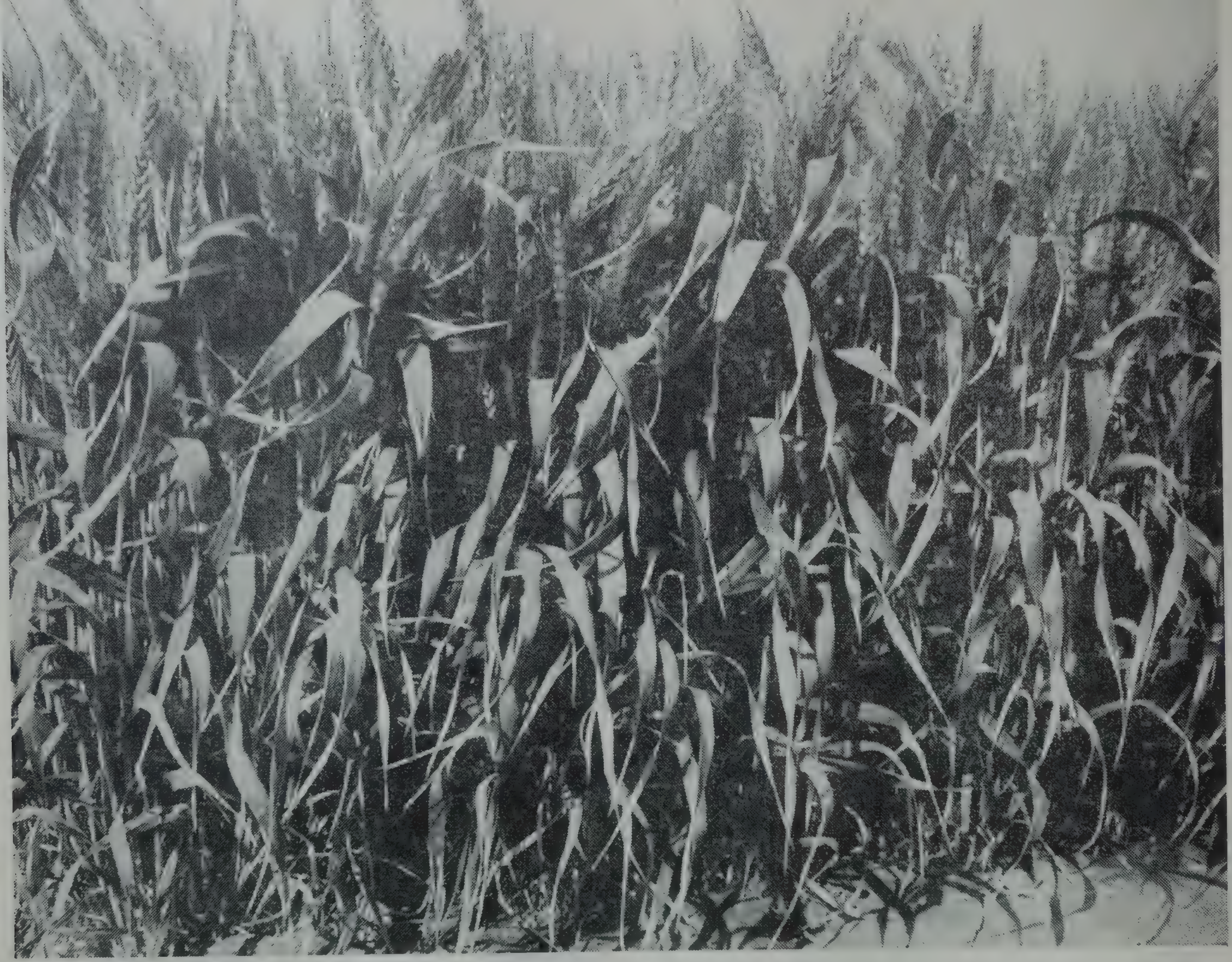

Fig. 1. Hira, a high-yielding variety of wheat

SCIENTIFIC BASIS FOR UPGRADING OF INDIA'S CROP PRODUCTION

H. K. JAIN

Indian Agricultural Research Institute, New Delhi

THE Hindustan centre of origin of crop plants described by the noted Russian geneticist Vavilov is one of the richest in the world. It has given to the world in one form or another some of the most important crop plants of our present day agriculture including rice, wheat, cotton and several of the grain legumes. Also, the Indus Valley is considered to be one of the oldest cradles of agriculture; archeological studies have shown that plants like wheat were under cultivation here long before similar advances were made elsewhere. One of the major objectives of agricultural research in India has been to transform this endowment of plant material into a rich source of national productivity and wealth. The work done at the Indian Agricultural Research Institute during the last 25 years has been an important step in this direction. India's crop resources today account for nearly 50 per cent of the Gross National Product of the country and also for nearly 40 per cent of the country's export earnings. The contribution which research has made to these resources can be seen from the fact that the high-yielding varieties of wheat alone have helped to increase the production of this important cereal from 12 million tonnes to nearly 25 million tonnes over a period of six years. This increased production has added nearly 1,000 crores of rupees to our national productivity, which constitute nearly 3 perc ent of our total GNP.

Perhaps the most significant contribution, which the Institute has made during the last 25 years is to take India to the path of modern agriculture, although we have a long way to go before we begin to exploit fully our diverse crop resources.

The High-Yielding Varieties Programme

The present day scientific agriculture with its high levels of production has been made possible largely by two scientific discoveries. The laws of heredity discovered by Mendel provided the scientific basis for the evolution of high-yielding varieties of various crop plants, and the earlier discoveries of Liebig and others in the field of plant nutrition have resulted in massive use of chemical fertilizers for crop production. It is the interaction between the high-yielding varieties and chemical fertilizers which has boosted crop yield all over the world to levels which were not thought possible earlier. In the case of India, the seeds of the improved crop varieties and their production technology have paved the way to our march towards modern agriculture. The Institute has collaborated with a number of national and international organisations, more particularly the Rockefeller Foundation which has given very valuable support, in this task of developing the high-yielding varieties and production techniques.

Wheat. The improved wheats produced at this Institute popularly known as the Pusa wheat showed for the first time that it is possible to combine good yields with desirable grain characteristics and a high degree of disease resistance. The Pusa wheats like NP 4, NP 52, NP 165 and subsequently the NP wheats of the 700 and 800 series became known all over the world. The more recent story of the introduction, breeding and release of the high-yielding varieties of wheat, in which this Institute has played a major role is well-known. These semi-dwarf varieties of wheat including Kalyansona, Sonalika and Sharbati Sonora have already made a major contribution to our national economy. Today the Institute has what has been described as one oı the largest wheat improvement programmes in the world and these efforts have resulted in the release of new varieties of the "triple" dwarf kind, which have given an yield of nearly 70 quintals per hectare within a maturity duration of 5 months. A number of these varieties including Hira, Moti and Shera have already been recommended for release and based on their per day productivity, they are some of the highest-yielding spring wheats in the world (Fig. 1).

Rice. The rice improvement programme of the Institute has been developed largely with a view to meeting the needs of those northern states, where there is a strong preference for fine grain varieties of the basmati type. A number of such varieties including Sabarmati, Jamuna and New Sabarmati have been released. Following the availability of these and other varieties, it is now expected that rice will become a far more important crop in the states of Punjab, Haryana, Western U.P. and Delhi than it has been in the past. Already, the new varieties are beginning to replace some of the traditional cereal crops like *bajra* and maize, which have been a major feature of kharif agriculture for hundreds of years in these states.

Maize. Scientific plant breeding recorded its first spectacular success with the development of hybrids of maize, which had such an important impact on the agriculture of the United States of America. In India, this Institute has been concerned with the development and release of a large number of double cross maize hybrids of the Ganga series, and the synthetic varieties like Kisan, Vijay and Vikram released in more recent years, which today cover more than half a million hectare of the total acreage under this crop. It has been estimated that the additional production resulting from the cultivation of hybrid varieties has added nearly 80 crores of rupees to our national productivity as shown in Table 1.

Sorghum. In respect of acreage, sorghum with its 18 million hectares, is the second most important crop in India. The Institute has played a major role in the development of high-yielding hybrids and varieties including CSH 1, CSH 2 and Swarna. The high-yielding varieties programme of the Government of India based on these hybrids has made a significant contribution to our agricultural production.

Strategy for a Short Term Production Advance in Pulses

Major advances have been made during the last ten years in the development of improved varieties of pulses, cotton and oilseeds, which should help to ensure that our agriculture shows a balanced growth and the production of crops of industrial, export and nutritional value does not suffer following competition from the high-yielding varieties of cereals. A number of new concepts in plant breeding based on harvest index, photoinsensitivity and improved plant-type have proved to be particularly rewarding in the lmprovement of these crops. Thus, a number of new varieties of *arhar* developed dur'ng the past 5 years are characterised by a high harvest index and short maturity duration. The new varieties allow much greater plant populations to be raised per unit of land than has been possible in the past. They include

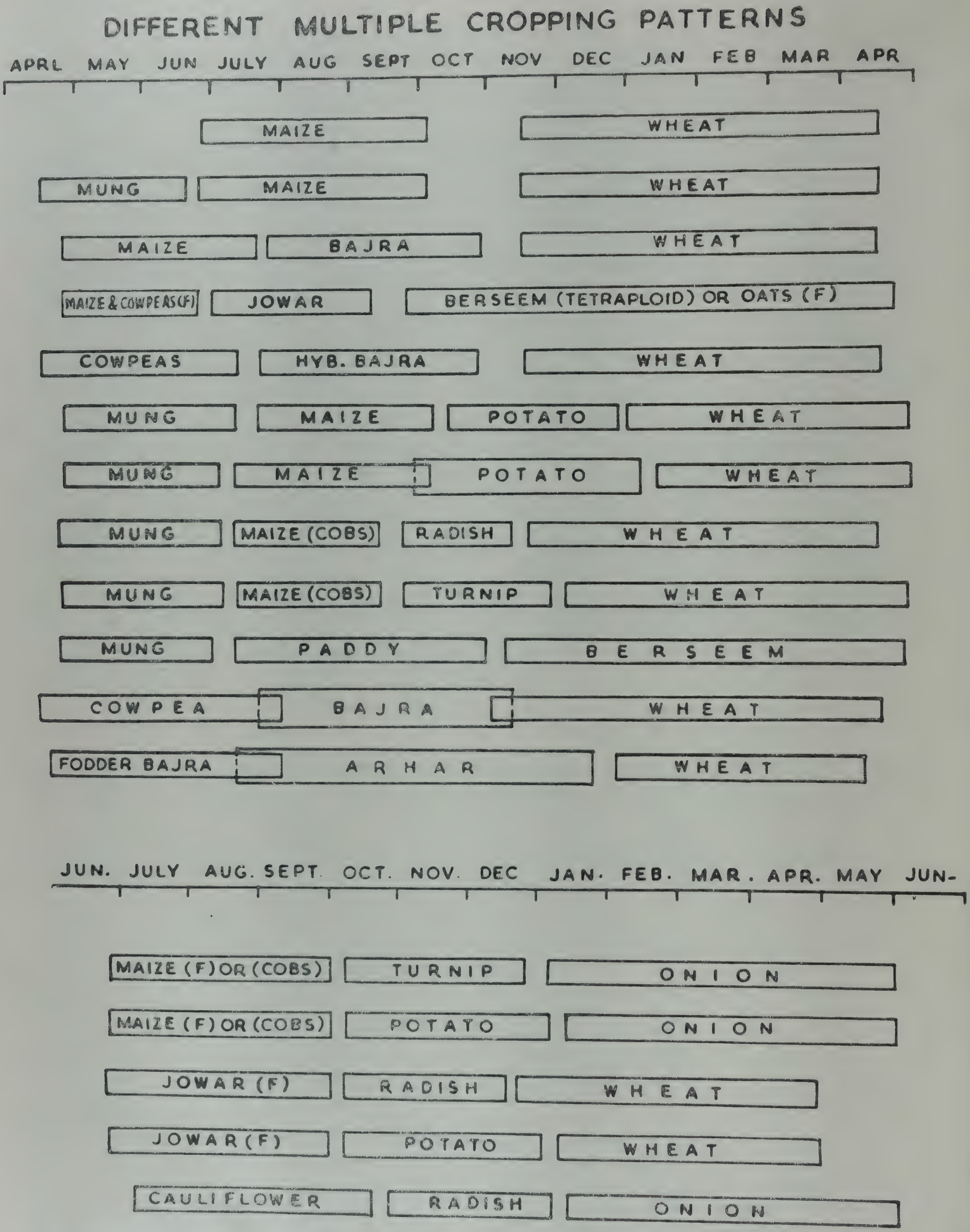

Fig. 2. Some of the different multiple and relay cropping patterns (Adapted from Recent Research on Multiple Cropping, I.A.R.I. Research Bulletin No. 8, 1972)

Pusa Ageti, Sharda and Mukta in the case of pigeon pea and Pusa Baisakhi in the case of *mung* bean. The latter can be harvested within a period of 70 days and can be grown as an additional crop during the summer months in between the main rabi and kharif seasons. In the case of another important pulse crop known as the *Khesari dal*, it has been possible to develop varieties, which are virtually free from neurotoxic materials. Nearly 5 million acres of this pulse are grown in India every year but consumption of its grains has continued to offer serious health hazards, because of these toxic components.

Based on their work on the development of improved varieties and a suitable production technology, scientists of this Institute have formulated a plan for a major advance in the production of pulses within the next five years. The main component of this production programme is the use of a package of improved practices, including fertilizers, pesticides and seeds of improved varieties. The second important component involves fitting the pulses in multiple cropping patterns making use of the short-duration varieties now available. The scientists of the Institute have successfully demonstrated that a number of pulse crops can be fitted in multiple cropping patterns so that it is now possible to produce from the same land over a one year period sizeable quantities of pulses in addition to large quantities of cereals. The third component of this strategy requires diversion of land from some of the less important kharif cereals like maize and bajra to pulses. The new varieties of pulses can profitably replace some of these cereal crops. This new development in Indian agriculture should be welcomed for the additional production of pulses achieved in this way would contribute to improved nutritional standards on the one hand and better maintenance of soil fertility on the other.

The diversification of the high-yielding varieties programme has also covered a number of other crops such as cotton, oilseeds, forages and vegetables. In the case of cotton, the Regional Station of the Institute at Coimbatore has released among others an outstanding *barbadense* variety, which is helping to meet the country's needs of fine quality cottons of the Egyptian type. With the availability of this and other varieties now in the breeders' assembly line, it is expected that the country will be self-sufficient in its requirement of raw cotton within the next two or three years. Already cotton production has increased to nearly 7 million bales, which is not very far from our present requirements at the current levels of consumption and export. Two important forages namely, Pusa giant napier grass capable of yielding about 1,000 quintals of green fodders per acre per year and Pusa giant berseem have been of very great value. The evolution of good quality mango through intervarietal crosses and development of seedless varieties of grapes have received attention from the scientists in the Horticulture Division. They have also released a wide range of vegetable varieties including Pusa purple long, P.P. round, and Pusa karanti brinjal variety, Pusa sweti and Pusa chanderma turnip, Pusa himani raddish, Pusa sharbati musk-melon and baidana water melon.

Nutritional Improvement of Food Grains

An important environmental factor which retards our national development arises from the problem of protein malnutrition. It has been established that deficiency of protein in human diet can bring about infant mortality, retarded physical growth, low work output, premature aging and reduced life span. The long term solution of the country's nutritional needs would be to increase greatly our supply of foods of animal origin including the various dairy products. A more practical solution in the context of our present economic conditions would be to increase greatly the production of protein rich food grains such as the pulses, and to upgrade our cereals like wheat and rice for their protein content and quality. The Institute during the last 10 years has helped to focus the country's attention on these problems and has developed into a strong research centre in this field. The new varieties of pulses can be expected to make a major contribution in this regard. It has also been possible to evolve new varieties of maize combining the opaque-2 gene, whose nutritional quality is of a very high order. Two such nutritionally superior composite varieties named Shakti and Ratan have been released and they show a 100 per cent increase in their lysine content and a 60 per cent increase in their tryptophane content. Children fed on opaque-2 maize from these strains showed as much gain in weight as a comparable group of children fed on skimmed milk. Thus, the new varieties of maize should help to eradicate malnutrition. Nutritionally superior varieties have also been developed in wheat, rice and other food grains.

New Production Technology, Multiple Cropping and Generation of Farm Employment

The Institute has been the foremost centre of agronomical research in the country and some of the findings from this work hold promise of giving a new dimension to our agriculture. The agronomy of the dwarf wheats developed by the scientists of this Institute has been described as the best in the world and has provided the basis for the exploitation of the dwarfing genes for a production breakthrough in a record time of less than five years. Even more important has been the theory and practice of multiple cropping developed by the agronomists of this Institute under the leadership of the late Dr S.S. Bains. Dr Bains described multiple cropping as a unique asset of the tropics and sub-tropics and an effective instrument for increasing the income of small holdings, banishing unemployment and under-employment on the farm, achieving stability of production in both irrigated and non-irrigated lands, and improving human nutrition and animal husbandry. Although the world knows India by its recurring droughts, the fact is that our country has the largest irrigated area in the world amounting to more than 26 million hectares. By making judicious use of short-duration varieties and suitable production and plant protection techniques, the scientists of the Institute have been able to raise four food crops, *mung*—maize—potato—wheat on the same piece of land in quick succession over a one year period. This combination has made it possible to harvest nearly 15 tonnes of food containing 1.76 tonnes of protein over a total duration of one year from a one hectare plot as shown in Table 2. The *mung*–maize–potato–wheat rotation has been the forerunner of series of other multiple patterns, which have been repeatedly demonstrated to the farmers on the Institute's farms and also in a large number of national demonstrations in different parts of the country. Some of these multiple and relay cropping patterns have given a net income of more than 5,000 rupees to the farmer from one hectare of land over a one year period. The profits have been higher when some of the food crops were replaced by vegetables. The scientists of the Institute appreciate that a large scale adoption of multiple cropping by our farmers requires a level of management, which may not be easy to achieve. Some of the most important requirements are the timely availability of various inputs, which call for heavy investment, and credit facilities without complicated procedures. Nor are the present varieties and the techniques associated with multiple cropping the best that can be developed. These are being constantly improved. With all these limitations, however, the scientists of the Institute remain convinced that this is the most effective production technology available to small farmers in countries like India for raising the economic and social status of the largest section of our society. It is also a most powerful tool for generating greater rural employment. Some of the more important multiple cropping patterns which have been successfully demonstrated are illustrated in figure 2.

TABLE 1. GAINS FROM THE HIGH-YIELDING VARIETIES OF MAIZE

(1970-71)

Total area under maize	5.84 million hectares
Area under H. Y. V.	0.60 million hectares
Total production	7.41 million tonnes
Average yield under high-yielding varieties	3500 kg/hectare
National average	1270 kg hectare
Gain	+ 2230 kg/hectare
Additional production due to high-yielding varieties	1.338 million tonnes

* Value of the additional produce Rs 80.3 crores

Value at Rs 600/tonne

TABLE 2. FOOD PRODUCTION PER HECTARE PER YEAR FROM 4 FOOD CROPS. MONG — MAIZE, POTATO — WHEAT

(From Scientific Multiple Cropping, Swaminathan et al. World Science News, **7** (7) 1-12 (1970)

Year	*Total food* (ton)	*Production* (ton)	*Production per day*	
			Flood (kg)	*Protein* (kg)
1966-67	13.7	1.59	38.6	4.5
1967-68	14.4	1.66	40.6	4.7
1968-69	14.0	1.62	39.4	4.6
1969-70	15.2	1.76	42.8	4.9

Technology for Dry Farming

While the multiple cropping techniques meet largely the requirements of farmers with irrigation facilities, the needs of India's vast dry lands have also received major attention. It has been possible to develop suitable varieties and production techniques for such areas so that the outlook for such farms is much better than it was only 10 years ago. The agronomists of the Institute have developed what is popularly known as the dry crop "cafetaria" which makes it possible for a farmer to choose the different combinations of crops, which would give the maximum returns under a particular set of climatic conditions. One of the important findings has been that crops like Brassica can profitably replace some of the traditional crops like wheat in our dry lands.

The Programme of national demonstrations

Not only has the Institute been concerned with the creation of new technology, it has also tried to make sure that the results of this labour are communicated to the farmer with the utmost speed. A classical example of this is provided by the successful transformation of a whole village in the Delhi state into a specialised seed producing unit. When the high-yielding dwarf varieties of wheat were first released, there was a major problem of rapid multiplication of their seed to meet the growing demand from all parts of the country. While the National Seeds Corporation played an important role in this regard, remarkable contributions were made by the farmers themselves. The farmers of the Jaunti village in the Delhi state were perhaps the first in the country to take up to scientific seed multiplication ensuring high standards of genetic and physical purity. Their example has been followed by many others since those early years. The entire Jaunti programme was conceived and steered by the scientists of this Institute. The communication of the new technology to farmers in the farthest corners of the country has been greatly helped by the programme of national demonstrations, which was launched by the Indian Council of Agricultural Research following a suggestion from the scientists of this Institute in 1965. This programme more than any other has helped to dispel the notion with the new technology is effective and yields results only on research farms. Extensive data is now available from the national demonstrations conducted on the farmers fields all over the country, which provide a convincing proof of the fact that the technology can be equally effective on the small holding of an average farmer. The Krishi Darshan Television programme of the all-India Radio pioneered by the scientists of the Extension Division of this Institute is also helping to take the new technology to the doorstep of farmers in the Union Territory of Delhi. This venture is now proposed to be extended to other parts of the oountry.

The New Technology and the Modern economic Theories of Indian Agriculture

The new agricultural technology developed by the sceintits of this Institute based on the outstanding contributions of scientists like Dr Norman E. Borlaug and their own studies has been an important factor in the economic and social advancement of the country. It has also served another useful purpose. It has been widely suggested by some of the noted economists of our time that almost all the ills of Indian agriculture arise from our social, political and cultural patterns, which have resulted in hardening of attitude, thinking and motivation. The foremost of them, Gunnar Myrdal, has argued in his celebrated "Asian Drama" that without any technological innovations and even without any investment, agricultural yields can be raised substantially in countries like India if only we can increase the productivity and work output of our vast labour force. According to him, the institutional reforms are far more important than the technological reforms. No one questions the value of institutional reforms in our agriculture, which are now fortunately receiving serious attention. The new technology, however, has shown that the Indian farmer with all his conservatism and lower status in the social heirarchy is perhaps not very different from his counterparts in other parts of the world. In any case the success of the new technology has clearly shown that technological reforms and capital investment in improved practices such as the use of fertilizers, improved seeds, pesticides, farm machinery and storage facilities can become major instruments of our agricultural reconstruction programmes.

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FISHERIES RESEARCH IN INDIA PRESENT AND FUTURE

R. RAGHU PRASAD and P.R.S. TAMPI
Indian Council of Agricultural Research
New Delhi

A TRULY organized approach to fisheries problems of our country has but a brief history, starting with the Central Fisheries Research Institutes exactly 25 years ago. Before that, some of the fisheries departments of the States have been conducting investigations on their respective local problems, the results of which have, no doubt, served as a useful starting point to plan the future strategies. Although twenty-five years are by no means a long period in the history of any biological research, especially taking into consideration the fact that the initial phase was devoted largely in organising a new set up, we may still consider that we have made rapid strides in the field of fisheries during this short span of time. Research constitutes the sheet-anchor for any developmental activity and fisheries is a sphere in which, during the post-independent era, we have been able to witness many notable developments. The country's fish production during the past two decades would bear ample testimony to the progress in our efforts to tap one of the important protein resources. India's position among the fish producing countries of the world has now come up to the seventh while in the Indian Ocean our preeminent rank at presents is undisputed.

Even a general study of the sequence of events that led to our present level of attainments will reveal that all these have been the natural outcome of a systematic build up. Several minor and some major achievements mark the path leading to our goal which, as in other fields, is self-reliance and self-sufficiency. Our country is so vast, the coast line so extensive and the fishing activities so erratic and disorganized that we had hardly any information of the amount of fish produced in the country every year. So one of our prime tasks was to make a satisfactory assessment of our resources and the output of manpower and effort expended for this annual production in order to help us in assessing the actual extent of exploitation. Where an enumeration is not feasible, a suitable system of sample survey had to be evolved and perfected to suit the peculiar conditions of the fishery. This has been achieved with a fair measure of success and as a result we have come to realize the country's potential as is evident from the trend in the increase of fish production, mechanization of fishing, export of fish and fish products, etc. This fundamental study was a revelation of the fact that our fishery resources were being considerably underexploited and there remained several regions whose potentials were virtually not tapped at all, partly because of our ignorance and also because we were ill-equipped for the purpose. Any body of water has its limit of natural biological productivity which is now gauged by the use of sophisticated techniques involving the use of radioactive carbon. By the application of this technique it has been found, contrary to some earlier belief, that at least, certain regions of our oceans are as productive as the temperate waters. Similarly, it is now possible to determine the productive potential of various types of inland waters in our country. All this have helped to enhance the rate of harvesting of waters that are rich or to adopt suitable management practices in areas which are less productive.

Our near shore and immediate offshore regions were subjected to systematic exploratory surveys. The result has been the discovery of rich fishing grounds, especially off the Gujarat—Maharashtra coast and also around the south-west and south-east coast. Rich beds of deep sea prawns and lobsters have been located in certain places and the fishing industry has been quick in taking advantage of these discoveries of recent times.

While the above relate to the capture fisheries of the seas, certain notable achievements have taken place with regard to freshwater fisheries. Fish culture in ponds has been an age-old practice in our country as in many regions of the orient. However, no efforts were made to develop this on scientific lines. Considerable investigations have gone into during the past twenty-five years in selecting the suitable species of for culture in the different types of agroclimatic conditions. Thus the methods for large scale culture of our major carps are now well-known to fish culturists all over the country. As carp culture became more and more popular, the industry was faced with the problem of obtaining sufficient quantities of seed fish required for stocking purposes as these young ones have necessarily to be collected from their natural source because the adult fish do not breed in captivity. The natural line of approach was to make an extensive survey and locate possible sources of seed collection and improve the collection techniques.

Significant Breakthrough

While this drive has been in progress, a significant breakthrough was achieved in this field when our researches succeeded in artificially inducing the carps to breed, through the administration of pituitary hormone extracts. This has opened up possibilities of obtaining pure quality seed for stocking purposes, in large numbers and more or less at will. To day, nearly ten years after the introduction of this technique, considerable refinement and some simplification including ampouling of pituitary hormones have been done leading to the wide application of the method all over the country. The next step in the offing is the setting up of pituitary banks so that the hormone for injection will be readily available with certain centralized agencies throughout the year.

Composite fish culture more or less follows the principle of mixed farming and rotation of crops in agriculture so that an available body of water is efficiently utilized. As farm fish are of different food habits, instead of adopting the technique of monoculture combinations of catla, rohu, mrigal, common carp, silver carp and grass carp are generally recommended for our waters, their exact proportion to be determined according to the amount and type of food material available.

While some of our indigenous species of carps are, no doubt, good for fish culture purposes, a continuous search has been going on for exotic fishes which could add to the list of culturable varieties. Thus those species which have been introduced and successfully used are the common carp, the silver carp and the grass carp, all of which are fast growers under tropical conditions. The grass carp has the unique advantage of making use of aquatic weeds for food and thereby helping in biological control of aquatic weeds. The imported *Tilapia* compensates for its small size by sheer numbers on account of its prolific breeding habits.

In nature no one species may be said to possess all beneficial characteristics. Therefore, research scientists in agriculture and animal husbandry have been constantly endeavouring to produce artificially hybrid varieties wherein the desirable qualities can be combined and as a result we now have several hybrid strains of crops or cattle that give excellent results. Likewise, the same principle is being adopted for producing hybrid fish although this is by no means an easy task on account of the breeding behaviour of fish. Recently, a few hybrid varieties involving the indigenous and exotic species have been experimentally produced which are undergoing tests before releasing them for culture operations.

Success in our fishing endeavours is largely guided by factors like a sound understanding of the behaviour of the fish in relation to their environment. In all these respects our researches have paid dividends, resulting in the designing of specialised gear suited for different types of fishing such as the four-seam trawl or the buldged belly trawl, calculated to enhance fishing efficiencies ranging from 30-70 per cent. Gear designs have been evolved for catching lobsters, prawns and pomfrets. Technological advancement in the designing of fishing crafts has been less progressive and has so far been restricted to boats of 7.6—18.42 metres in length. With the introduction of these designs it has become possible for the fishing industry to take advantage and substantially improve the catch per unit effort.

Packaging and Processing

Catching more fish from the sea is not an end in itself. Unless we know how to make the best use of all the fish that is taken out of the sea, our efforts should be considered a waste. Fish, especially in the tropics, tend to lose their freshness in a short time unless steps are taken to preserve them properly. While the principle of preservation of perishable commodities in ice has been well-known, the use of ice in the preservation and transport of fish has never been so popular as it is today. The result is that fish eater in Delhi or Calcutta is able to buy his favourite prawn or pomfret, caught in far off Cochin or Veraval, from the local market where he is assured of their reasonable freshness. Packaging and processing of perishable products have since been revolutionised and have become so popular that in almost all cities we find facilities for cold store for large scale and retail markets. The various aspects relating to freeze preservation of fish have been scientifically analysed by our research scientists who have been able to guide the industry in the proper and successful application of the freezing technique. The same applies to other forms of processing technology. The impact of research on fish processing technology during the past couple of decades has been such that there has been a phenomenal boom in fish processing industry. With constant advice from our research scientists, the fish processors and exporters have been able to adopt some of the highly sophisticated methods and bring their industry to a high level of perfection. Our country is exporting a variety of marine products to a total worth of Rs 39 crores and it should be a matter of great pride to us that even the highly discriminating consumers have come to accept the products exported from India. Thanks to the high quality standards prescribed by our fishery technologists and voluntarily accepted by the industry, that but a very negligible percentage of our exports are now being rejected by the foreign consumers. Summing up, it may be said that while our achievments in the field of fisheries may not be of a spectacular nature, all our research activities during these years have taken us a long way towards our goal for increased production of protein rich food and also helped towards the improvement of the economy of the weaker section of our rural population.

Future Approach

In the foregoing account an attempt has been made to highlight the major advances and significant milestones in the field of fisheries research during the last 25 years. Indications have also been given on the lines on which important research work is being carried out. Although fisheries research in this country has received considerable impetus during the past two and a half decades much more remains to be accomplished in this field in view of the fact that there is an urgent need for increasing fish production to meet the chronic protein shortage, step up export, develop aquaculture as an organized industry so that these will help in the improvement of our rural economy.

Viewed in this background the future approach is to increase the marine fish production by locating hitherto under and unexploited resources, evolve techniques for capture of those varieties which are somewhat dispersed in their distribution, develop more efficient yet cheap fishing crafts, gear and fishing accessories, invent suitable import substitutions to reduce our dependence on foreign materials and enhance mechanisation in fishing operations so that resources from the offshore regions can also be tapped to a much greater degree than is being done at present. Increased emphasis is being laid for improving the techniques for preservation and processing of fish for internal consumption, elimination of wastage and fuller utilization of uneconomical varieties of fish, not only as manure and animal feed but also for human consumption. Acquaculture in fresh and saline waters is to be intensified in order to utilize all available watersheds for fish production. In this venture attempts will be made for increasing the production of seed fish, refinement in the technique of induced breeding of cultivable fishes, isolation and purification of the active principles of pituitary hormone responsible for reproduction, hybridization and selective breeding of fishes for evolving new varieties for culture, and introduction of selected varieties of exotic fishes for stocking in reservoirs. Intensive research to develop inland fishing gear and similar important projects of immediate application will figure more in future in the field of fisheries.

The recent launching of seven all India coordinated research projects in fisheries by the I.C.A.R. marks the beginning of a new era in fisheries research. This is a novel approach towards finding speedy solutions to problems concerning fisheries of the country as a whole, as opposed to regional problems. This is a unique endeavour where the research scientists of the Centre and the States co-operate in a time-bound programme. Such a cooperative approach is bound to pay rich dividends and help us in the ultimate progress and rational exploitation of our fishery resources.

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RICE RESEARCH AND DEVELOPMENT

S. Y. PADMANABHAN
Director, Central Rice Research Institute, Cuttack

RICE Research was initiated in India in 1913 with the appointment of Rice Specialists in Bengal and in Madras. Subsequently, most of the States in India organised rice improvement programmes. Besides the principal rice research stations, several sub-stations were established to cater to the needs of different agro-climatic zones in each State. Today, we have more than hundred research stations and sub-stations devoted to rice research in the country.

About four hundred improved varieties of rice were released by these stations prior to 1947, mostly representing single plant selection from cultivators' bulk. Some of the outstanding varieties released during this period like G.E.B. 24, Latisail, etc., still cover a large area in the country, A few Chinese introductions found favour in Kashmir, Himachal Pradesh, and Uttar Pradesh.

In view of the pivotal role of rice in the agricultural economy of India, the Government of India established the Central Research Institute in 1946, a year before Independence, to undertake research on all fundamental and applied aspects of rice culture.

With the attainment of independence a new thrust was given to rice research, International contacts widened the horizon, purposiveness and content of research.

The International Rice Commission of the F.A.O. allotted high priority to the maintenance of rice germplasm collection and their cataloguing. The Central Rice Research Institute was selected as one of the main centres for the maintenance of the world germplasm collection of rice.

High-yielding Varieties

Basic studies led to the conception of a plant ideotype for high yield (semi-dwarf, non-lodging with erect or semi-erect leaves which do not shade one another). DE-GE-WO-GEN and Taichung (Native) I were identified as conforming to such an ideotype. They had high nitrogen responsiveness and were capable of yielding seven to ten tonnes for hectare against three to five tonnes given by traditional varieties. Taichung (Native) I was introduced in India in 1965 and was followed by IR.8 bred at the International Rice Research Institute.

To improve the grain quality of high-yielding varieties, to incorporate a certain amount of tolerance to pests and diseases to which the high yielding were particularly susceptiable, and to have varieties of different duration, a crash breeding programme was initiated in November 1965 under the auspices of the All India Coordinated Rice Improvement Project sanctioned by the ICAR.

This programme has resulted in the release of 15 high-yielding rice varieties, through the Central Variety Release committee and 12 varieties by the State Variety Release Committees.

Of these, Jaya has occupied large areas in Punjab and Haryana in kharif and in other rice growing States in the rabi season. The varieties Bala, Ratna and Vijaya are gaining ground and are expected to be cultivated in large areas with improved position of seed supply. The varieties Pankaj and Jagannath are finding some favour with the farmers of the coastal States in the kharif season.

Basic physiological data on productivity and genetics of various characters including disease resistance have been obtained which would be of great utility in intensification of varietal improvement programme.

Rational use of Fertilizers

With the release of these new varieties, the package of fertilizer practices for the new varieties were worked out. From information of basic nature obtained at the Central Rice Research Institute, a group of tentative fertilizer schedules on the rates and time of applications were formulated and these were tested in the different agro-climatic zones in the country through the AICRIP.

These results suggest that the optimum nitrogen rates for the new varieties were 80-120 kg/ha in kharif and 120-150 kg/ha in rabi. Fractional application of nitrogen resulted in better efficiency per unit input compared to that when the entire amount was applied in a single dose.

In view of the shortage of fertilizers in the country, low level economic conditions of the farmers and lack of crop insurance, fertilizer recommendations to the farmers have been based on the rate at which the benefit/cost ratio is nearly 2. The benefit/cost ratio worked out for different rates of nitrogen application show that 80-120 kg/ha in kharif and 100-120 kg/ha in rabi are the economic optimum.

Simple fertilizer trials in farmers' fields and soil test-crop response correlation studies conducted under other All India Coordinated projects of the ICAR have resulted in identifying areas which show response to the application of other nutrients like phosphorus, potassium and micronutrients. These results show that more and more areas need application of phosphorus for balanced nutrition and that areas in Punjab, Haryana, Uttar Pradesh and Andhra Pradesh are prone to Zn deficiency.

Judicious Use of Water

Results from work on water use efficiency conducted at the CRRI showed that it was possible to effect about 40 per cent economy in water use through judicious water management without sacrificing grain yield. These findings have been demonstrated by the CRRI in collaboration with the Department of Agriculture, Government of Orissa in a 100 acre block in the vicinity of the Institute and during the first year, it was possible to bring an additional 40 acres under cultivation with the available water supply. Similar pilot demonstrations are being planned in collaboration with the Department of Agriculture, Bihar, in the Sone and Gandak Command areas. Extension of these results to farmers field, however, needs contour mapping, provision of field channels along the contours and if possible lining of the channels.

Pests and Diseases

The new varieties are susceptible to a large number of major diseases and pests like bacterial blight, stem-borer, gall midge, tungro virus, etc. Pests like plant and leaf hoppers, leaf roller and cut worm which were considered minor pests prior to the introduction of high-yielding varieties have now become major pests. Fortunately, most of the released varieties except Ratna, Cauvery, Kanchi, Jagannath possess some degree of resistance to the blast disease. Ratna has tolerance to stem-borer during the earlier growth stages while Vijaya possesses tolerance to leaf hoppers, stem-borer and Tungro virus.

Studies on the control of diseases and pests have resulted in evolving a combination of cultural practices like time of sowing and transplanting, spacing, etc. with spray or soil application of pesticides—Hinosan and Kasumin against blast, Diazinon, Parathion, Malathion, Thiodan etc. against stem borers and to some extent against gall midge and leaf hoppers, to bring about some amount of control particularly for the pests.

In an effort to familiarize the farmers with this new technology of rice production with the high-yielding varieties, the programme of National Demonstrations was taken up simultaneously in 1965. The philosophy behind this was that the research scientist should himself be able to demonstrate high production to the farmer. During the first two years the effort was mainly on monoculture of rice which was subsequently extended to different cropping patterns with an objective of optimizing production per unit area for unit time.

The average yields of rice in the National Demonstrations varied from 41.95 to 59.46 gl/ha in the last five years with phenomenal high-yields by individual cultivators, in each year. It was further observed that 62-87 per cent farmers obtained yields higher than 4 tonne/ha. It was observed that in multi-cropping of rice, the target yields of 9 tonne/ha for two crops and 11 tonne/ha for three crops was exceeded by 94-100 per cent of the farmers in different years whereas in the other patterns, the range was 63-90 per cent. The National Demonstrations have thus indicated the potential and the scope for prosperity with the new varieties and the new technology.

Besides direct demonstrations of the new production technology in the farmers' fields, practical training programmes for various levels of Extension Workers have also been instituted. The Officers trained in these programmes in turn organize state, district or block level training for the benefit of other extension workers and farmers.

Area and Production

In the year of independence in 1947-48, the total area under rice was 26·4 m ha with a production of 19·9 m tonnes, with an average yield of 808 kg/ha. During the first five years of independence there was a marked increase in the growth rate of area (3.5 per cent per annum) which, however, resulted in only a corresponding growth rate of 1·3 per cent per annum in production. During the subsequent periods, the growth rate in area has been in the range 1·3 to 1·9 per cent with an encouraging production rate in the range 4·0 to 6·1 per cent. This has been possible because of intensification of research and development work on agriculture in general and rice in particular during the 2nd, 3rd and 4th five year plan periods, despite lean years due to highly adverse climatic conditions especially in 1965-66 and 1966-67.

According to the latest production figures of rice in the different States of India, while the southern states, the Punjab and Haryana have attained yields about that of All India average, the north eastern rice growing region, comprising eastern U.P., Bihar, Bengal, Madhya Pradesh, Orissa and Assam is of low productivity. Intensification of the drive for rice production in these region is of immediate importants to raise the average rice production level in the country.

The area under second crop of rice, i.e. rice grown in December to May is hardly two million hectares. The yield potential of the high-yielding varieties is best expressed in the second crop season with clear sunlight and controlled infection. An extension of the second crop area to 5 million hectares before 1973-74 is a desirable and feasible objective with an average yield of 4 to 5 tonnes per hectare. A production of nearly 20 million tonnes would be achieved which would be an insurance against the vagaries of the monsoon in the kharif season. Before 1980 we should strive to increase the second crop area to 10 million hectares.

New varieties in the Assembly line. Because of the diversity of growing conditions in kharif it may be more appropriate to have sets of varieties for different agroclimatic regions and within a region a choice of varieties must be available for varying crop sequences.

From fundamental studies conducted at the CRRI, the criteria for tolerance or resistance to specific environmental stress situations have been identified and simple techniques have been devised for screening of large population. These techniques have been used to screen the rice germplasm collection of the institute and suitable donors have been indentified and used in the new breeding projects.

Integrated Control

Use of biocides has been one of the major causes for environmental pollution in agriculture. Efforts are being made to minimize environmental pollution through an integrated control measures, work on which has already been initiated. This envisages suitable crop rotations, use of genetic resistance of crop varieties coupled with use of bioagents clean cultivation and minimum use of pesticids. Surveillance and forecasting techniques for pests and diseases, will be used to warn about the out break of epidemics.

With the extension of multiple cropping, there will be need for water for intensified cropping all round the year. Techniques have to be evolved for equitable distribution of available water to crops all round the year which calls for studies on water harvesting, water storage, judicious management, improvement of irrigation and drainage structures, etc. The Indian Council of Agricultural Research has launched several coordinated projects like Dry Farming Research, Water Management and Soil salinity, New Cropping Pattern and Water Use, etc. Besides, a Water Technology Centre has been established at the IARI and Irrigation Agronomy Sections at the Central Research Institute and Agricultural Universities have been strengthend. It is hoped that the coming years will see measures which will optimize water use efficiency for different crops for maximizing production per unit area per unit time.

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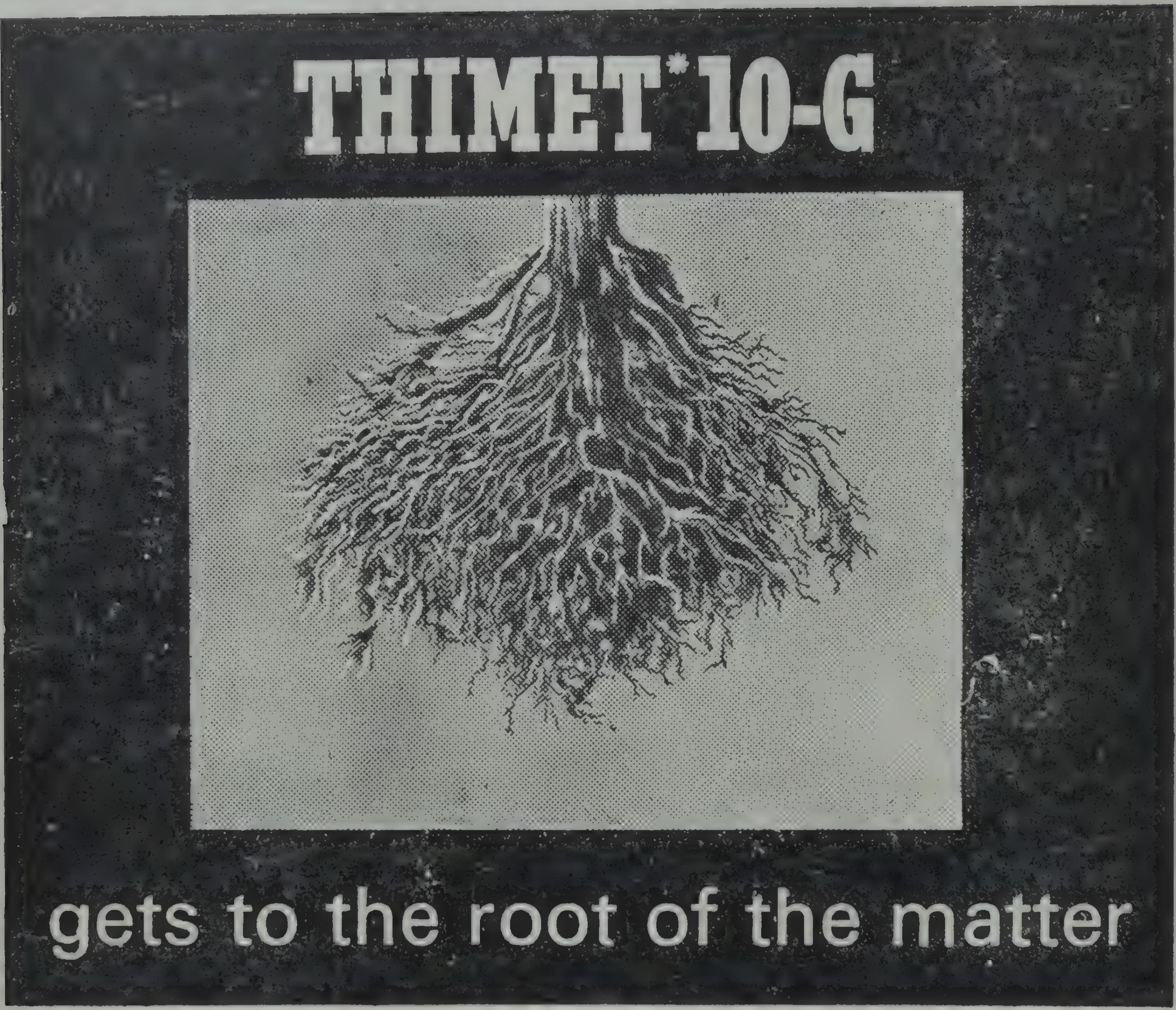

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TWENTY-FIVE YEARS OF WHEAT RESEARCH IN INDIA

M.V. RAO
Project Co-ordinator (Wheat), Indian
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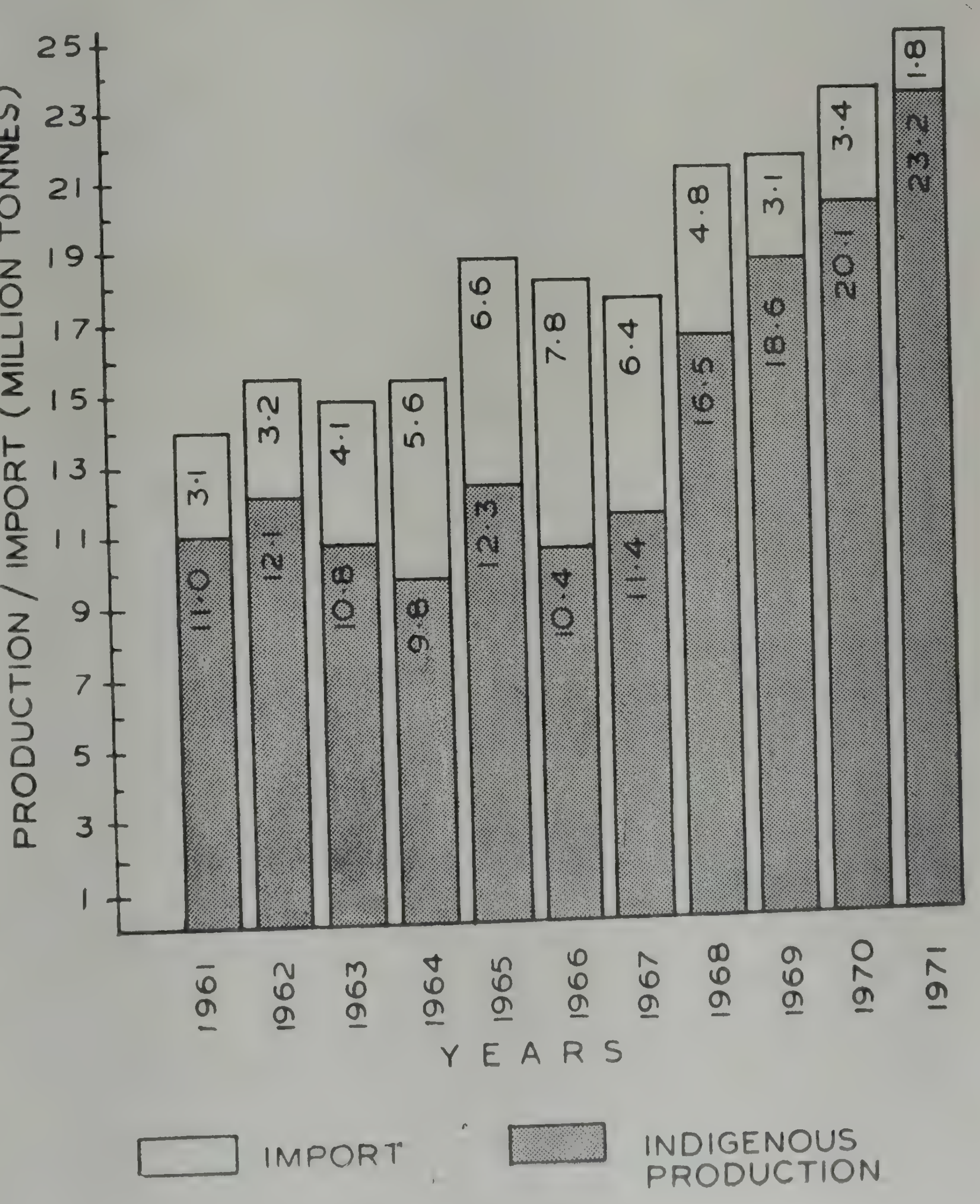
When India won its Independence in 1947, it suddenly found itself to be deficient in wheat—the second most important cereal food crop of the country. The production was 5.6 million tonnes which was not sufficient to meet the local needs. Added to this there was a severe epidemic of rust in Central India leading to widespread devastation to the standing wheat crop. Large quantities of food grains particularly wheat, costing about Rs. 93.99 crores had to be imported in that year. The imports increased and the amount spent on food imports reached the phenomenal figures of Rs. 523.13 crores in 1966 and Rs. 532.16 crores in 1967. Now in 1972 the story is different—India not only produces enough wheat to meet the needs of its growing population but it is having surplus stocks of wheat and is even thinking in terms of exporting wheat. In 1970-71 we harvested 23.1 million tonnes of wheat. The 1971-72 crop has been estimated to give 26.0 million tonnes. Thus the wheat production in India has been increased by five times since Independence. How this great success has been achieved is an interesting story, unparalleled in the annals of agricultural history of any country. The wheat revolution is an example to show how success can be achieved through a coordinated and combined efforts of scientists, farmers, administrators, and other agencies.

Wheat in the Economy of the Country

Before proceeding to review the work of 25 years of wheat research in India it would be pertinent to state a few facts about wheat in general, in the economy of the country. In 1947 the area under wheat was 9.2 million hectares producing about 5.6 million tonnes. The yield due to a variety of reasons, was very low—660 kgs/hec. Seventy five per cent of the area of wheat was grown under rainfed conditions. Through bringing in more area under wheat the production of this cereal was increased in the 50's but the per hectare yields remained more or less at the same level. A new strategy had to be worked out to increase per hectare yields since there is a limitation of the cultivable land. The new strategy thought about in 1963 bore its fruit in the crop season of 1967-68 and since then the wheat production has been continuously rising till today. The scope for further increasing the wheat yields is very high.



India is the third major wheat growing country in the world contributing 5.8 per cent to the total wheat production of the world. The U.S.S.R. which produces 27.9 per cent of the world's wheat, stands first followed by the U.S.A. which produces 12.5 per cent. Area-wise again India is third (with the present acreage of about 17.9 million hectares) only to be superceded by the U.S.S.R. and the U.S.A. with 65.5 and 18.0 million hectares respectively. With the trend in U.S.A. to cut down wheat acreage, perhaps India may come to occupy the second position in the world as far as the wheat acreage is concerned. The per hectare yields in the U.S.S.R. and the U.S.A. are 17.9 and 20.9 quintals as compared to 13.0 quintals in India. These figures are low when we compare the per hectare yields obtained by the U.K. (41.3), West Germany (37.9), France (34.4), Mexico (28.4) and Canada (20.9). When we take into consideration that in India where 50% of the wheat acreage is under rainfed conditions and where the average yields range between 4-5 quintals/hectare, the 13.0 quintals/hectare of national average is not a low figure. In some of the major wheat surplus countries like Australia the national average of wheat yield is 11.5 quintals hectare. In irrigated areas of India where intensive agriculture is practised some of the Krishi Pandits recorded as high as 100 Quintals/hectare. In the Ludhiana district of Punjab which is the wheat granary of that State, the yields are as high as 45 quintals/hectare. While only one crop is grown in a year in the temperate countries like Netherlands, the U.K. etc., at least two, if not three crops are raised in districts like Ludhiana in the same year. The National Demonstrations show the tremendous possibilities of increasing our wheat yields.

In India, wheat occupies 14.5 per cent of the total area under food grain crops and is only surpassed by rice (30.2 per cent) and, all pulses put together (18.1 per cent). However, in production it contributes 21.6 per cent of the total food grain production of the country, while rice contributes to 39.5 per cent. Although Jowar has nearly as much area as that of wheat it produces only 1/3 of wheat production viz., 7.6 per cent. In 1947 the contribution of wheat to total food grain production of India was only 9.2 per cent while now its contribution is 21.6 per cent.

Wheat is grown in most of the states of India with the exception of few states like Kerala. The following are the important wheat growing states and their percentage contributions in terms of national wheat area and production (1970-71).

State	*Percent of National wheat area*	*Percent of National wheat production*
Uttar Pradesh	32.8	31.6
Madhya Pradesh	18.6	10.6
Punjab	12.4	20.4
Rajasthan	8.2	8.2
Bihar	6.9	5.0
Haryana	6.2	9.8
Maharashtra	4.9	3.7
Gujarat	3.3	3.9
Other States	4.7	6.8

Most of the wheat grown in India belongs to the bread wheat group (87 per cent) used for 'Chapati' and bread making purposes. About 12 per cent is under the macaroni wheat used for making suji, samolina, spheghetti etc. A little less than 1 per cent is under the emmer wheat suitable for 'uppumav'. The wheat revolution is so far confined to the bread wheat only.

Impact of the Wheat Revolution

The 1964-65 crop season was considered to be the best year for production, before the high yielding varieties and the new scientific technology ushered in the wheat revolution. The impact of the wheat revolution, which started in 1967-68, can be judged by the figures in the next column.

Year	*Production* (in million tonnes)
1964-65	12.3
1967-68	16.5
1968-69	18.7
1969-70	20.1
1970-71	23.2
1971-72 (estimated)	26.0

Thus between 1967-68 to 1971-72 the wheat production got more than doubled, over the 1964-65 production. This phenomenal increase in wheat has no parallel when we compare with other crops in India as judged by the following figures: (next column.)

Crop	*Production in* 1964-65 (in million tonnes)	*Production in* 1970-71 (Million tonnes)	*Increase-decrease over the* 1964-65 *figure* (Million tonnes)
Rice	39.3	42.4	+ 3.1
Wheat	12.2	23.2	+11.0
Jowar	9.6	8.2	— 1.4
Bajra	4.5	8.5	+ 4.0
Maize	4.6	7.4	+ 2.8
Pulses	12.4	11.5	— 0.9

Upward Trend in Production

The per capita production of wheat has been showing a steady upward trend. In 1965 it was 25 Kgs., in 1968 (when the high yielding varieties and new technology have spread to the farmers fields) it rose to 33, in 1969 to 35, in 1970 to 37 and in 1971 to 41. The figure for 1972 is expected to be around 45. Thus in a short period of 5 years commencing from 1967 there was a near doubling up of per capita production over the 1964-65 figure.

The impact of the wheat revolution can also be judged by the reduction in imports and saving of valuable foreign exchange. Between 1947-70 India imported food grains worth Rs. 4563 crores. The indigenous production and the extent of imports India was making since 1961 is shown in figure 1.

While we imported 7.8 million tonnes in 1966, the figure gradually came down to 1.8 million tonnes in 1971. In 1972, the Silver Jubilee year of India's Independence, the Government of India has felt it no more necessary to depend on foreign countries for wheat imports and has decided to suspend all wheat imports. In fact in 1970 India has started exporting wheat products like *atta*, flour etc. on a modest scale (20,000 tonnes). According to U.S. Agricultural Department report India is expected to export 650,000 tonnes of wheat in 1972.

What has been achieved by the farmers during the last 25 years in India, particularly during the last few years is the result of multi-disciplinary approach and the vision of few dedicated scientists and robust support of administrators, politicians, and, certain agencies like the Rockefeller Foundation who helped to get the wheat germplasm from Mexico. The ready acceptance of the new technology and the confidence of the farmers on the scientists was the key factor for the success. Each of the disciplines namely, breeding, genetics, agronomy, pathology, entomology, extension, agricultural engineering, soil chemistry etc., all contributed to this green revolution. The work of each of these disciplines during the last 25 years is briefly reviewed here.

Contributions of Different Disciplines

Breeding. The breeding work done in the past was devoted primarily to the development of tall conventional varieties known for their excellent grain appearance and soft pliable straw to be used as feed for the cattle. Some of the varieties released after 1947 such as NP Nos. 710, 718, 761, 770, 775, 792, 797, 798, 799, 809, 818, 824, 829, 830, 835, 836, 839, 846, 852, 875, 880, 884 and 890; Pb. C. Nos. 281, 273, 285, 286, 303, 306; Hy. Nos. 11, 38, 65; K. Nos. 65, 68; RS 31-1, Kenphad Nos. 21, 24, 25, 28 etc., along with some of the wheats bred earlier such as Pb. C. 591, Pb.C. 518, NP 165, Niphad 4 were grown widely in the country. Being tall they tended to lodge when intensive agriculture is followed. The break-through in production possibilities came with the identification in 1963 of short-stiff strawed, photo insensitive wheats developed by the Nobel laureate Dr. Norman E. Borlaug in Mexico. In April 1966 the Government of India took a bold decision of importing from Mexico 18,000 tonnes of seed of two varieties Lerma Rojo-64A and Sonora 64 to distribute to farmers in India. Although high yielding, these varieties being red grained did not become very popular. Another variety PV 18, although high yielding had the same defect of red grains. But these were soon replaced by other amber seeded wheats like Kalyansona, Sonalika, Chhoti Lerma, Safed Lerma and Sharbati Sonora (an amber seeded mutant of original Sonora 64). In 1966-67 about 0.5 million hectares were put under these dwarf wheats. In 1970-71 the area under these wheats rose to about 6.5 million hectares which further increased in 1971-72 to cover most of the irrigated areas and more than 40% of the total wheat area of the country. In the last 2-3 years triple dwarf wheats like Lal Bahadur, UP 301 and Hira, single dwarf wheats like NI 747-19 and NI 5439 and the conventional types like Narmada-4, A 9-30-1 (for the low fertility rainfed areas of Central India) have been released. Some of these dwarf wheats have higher yield potential, better grain quality than the original wheats obtained from Mexico and, reselected in India.

Once varieties with the new plant type that is responsive to higher levels of fertilizer application and better management practices were available they acted as catalysts. New agronomy, new crop management and irrigation practices had to be developed to get the best out of them. National Demonstrations which were organised on a country-wide basis convinced the farmers of the superiority of the new wheats and the new technology, as a result he readily accepted them. This is a great achievement of the high yielding varieties programme. Some of the greatest advantages of the new dwarf wheats is their suitability for late sowings. Some of them like Sonalika and Sharbati Sonora could be sown as late as end of December on fields which otherwise would have been left fallow. The other great advantage of these wheats is their suitability in the multiple or relay cropping on which our strategy, besides other things, for stepping up production per unit area per year, is based. In serveral parts of Uttar Pradesh wheat is grown as a companion crop of sugarcane without affecting the sugar yields.

Better varieties of wheat are now in the assembly line of the breeders. They combine stiff straw, better grain quality, greater resistance to diseases and pests.

Agronomy. The agronomy played a very significant role in maximising the yields once the right plant types were identified. A whole schedule of practices such as depth of planting (the dwarf wheats have short coleoptile and hence if the seed is planted deep as in the local conventional tall wheats, the stand suffered), time and number of irrigations (the first irrigation at the crown root initiation stage was crucial followed

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by 3-4 subsequent irrigations), fertilizer schedule, seed rate, spacing between rows, foliar application of fertilizers etc. were all worked out. The soil tests coupled with suitable fertilizer and water management schedules enabled our scientists to suggest measures to achieve specific targets of production.

Plant Protection. Wheat in India is attacked by more than 16 different diseases out of which the rusts, the smuts and, the leaf blights are the most damaging. They visit us every year and about 10 per cent of the total production is effected because of them. In years when these diseases appear in epidemic proportions then the losses could be very high or sometimes, even total. Wheat pathology through systematic disease surveilance, race analysis, in finding suitable chemicals to control the diseases, in artificial creation of epidemics in the breeders plots greatly helped the total wheat programme of the country. The plant pathologists keep the breeders regularly informed of the new races of disease causing pathogens that could be dangerous to the wheat crop.

So far no field pests except the white ants, stem borers and cutworms are serious on the standing wheat crop. Army worm in recent years is posing a problem in certain areas. Suitable pesticides have been identified by the entomologists that effectively control these pests. But the greatest damage to wheat is due to the stored grain pests out of which the lesser grain weevil and the rice weevil are the most important. In fact it is estimated that 10 percent of the grain produced in Inia is lost due to these store grain pests. Suitable storage bins and chemicals were found to minimise the losses of wheat grain in storage. Some of the diseases caused by nematodes like the molya disease and the ear-cockle and 'tundu' complex have been found in the north western parts of India and wheat varieties resistant or tolerant to these diseases and chemicals to control the pathogens have been identified.

Quality. The conventional Indian wheats although have excellent grain characters and 'chapati' making qualities many of them are not suitable for bread making purposes. However, some of the wheats like NP 4, NP 871, NP 880, NP 890, K65 K 68 are excellent for bread making purposes. Among the dwarf wheats Sharbati Sonora, UP 301 and Hira are admirably suited for bread making. The tests conducted by the bakeries and cereal quality testing laboratories in India have shown that the bread made from wheats like Sharbati Sonora can be compared to the bread made out of the best imported wheats. The Indian wheat breeders have now produced strains which are good in quality, high in protein and have reasonably appropriate quantities of lysine.

Besides improving the common bread wheat (*Triticum aestivum*) the Indian scientists have not lost sight of developing better strains of the other two species grown in India viz., the macaroni wheat (*T. durum*) and the emmer wheat (*T. dicoccum*). Some of the macaroni wheats like NP 406, NP 412, Hy. 23, N 111, N 1200, A 206 Bijaga Yellow, Bijaga red Amrut, A 9-30-1 and the emmer wheats like NP 200, NP 201 developed in the last 25 years are widely grown in Central and Peninsular India. The breeders have been successful in identifying or producing dwarf durum wheats, similar to the dwarf bread wheats, that could be grown under high fertility irrigated conditions (the durum wheats so far are grown under rainfed conditions only). The dwarf durums should spark off new production levels in the very near future and help the country in exports.

Organisation of wheat research in India

The wheat research in India at the time of Independence was done at few centres of the Central and State governments. It was not sufficiently geared to work at a national level in a coordinated and colloborative way but was mainly restricted to regional or specific problems. The emphasis before Independence was more on cash crops like coffee, tea, rubber, cocoa, tobacco etc. than on food crops like wheat. Thus there was a technology gap with regard to improvement of food grain crops in general. Now India can boast of having one of the most diversified and aggressive wheat programmes in the world. The whole work of the country is coordinated under the All India Coordinated Wheat Improvement Project of the Indian Council of Agricultural Research. The work of the Central and State agencies is coordinated on a multi-disciplinary basis, involving such disciplines as breeding, genetics, cytogenetics, agronomy, plant pathology, entomology, nematology, soil chemistry, quality, agricultural engineering, extension and physiology. The whole wheat work is coordinated by the All India Wheat Project Coordinator who is helped by Principal Investigators in major disciplines of agronomy, plant pathology, quality and physiology. On the basis of soil and climatic conditions the country is divided into five major wheat Zones viz., the north western plains zone, consisting of the States of Punjab, Haryana, Rajasthan and Western Uttar Pradesh; the north eastern plains zone consisting of the States of Bihar, West Bengal, Orissa, Assam and eastern Uttar Pradesh; the Central zone consisting of the states of Madhya Pradesh, Gujarat and south-central part of Uttar Pradesh and south-eastern part of Rajasthan; the Peninsular zone consisting of the states of Maharashtra, Andhra Pradesh, Mysore and Tamil Nadu and finally the northern hill zone covering the hilly areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Bihar and West Bengal. Work in each of these zones is coordinated by a Zonal Coordinator. A number of stations in each of these five zones work on wheat improvement. To hasten the breeding and disease screening work, stations were developed in the hills of north India (Lahaul valley in Himachal Pradesh), and south India (Wellington in Nilgiri hills). At both these locations a second crop of wheat can be raised in the summer months. Every year at more than 400 centres All India coordinated wheat trials and other experiments are carried out. Data of all these trials and, other research findings of different workers in the country, are discussed annually in the All India Wheat Workshop meetings and, recommendations are made for the benefit of the overall wheat economy of the country.

Problems and Prospects

The problems of wheat crop cannot be considered in isolation but should be considered in relation to other crops and developments of the country. Although we achieved self sufficiency in wheat and even having surplus stocks now there is no room for complacency. A number of problems still are to be solved and a number of new problems are arising.

There is a tremendous scope for further increasing our average yields particularly in irrigated areas. The yields obtained by Krishi Pandits in the All India Crop Competitions, in the National Demonstrations and in the All India Coordinated yield and agronomic trials clear indicate the extent and scope for getting higher yields. With the growing population, demands for an important cereal food crop like wheat would always increase and efforts should not be relaxed in producing better varieties and better production practices.

Diseases and Pests

There is a great need to save the wheat crop from ever increasing disease and pest menace. New races of the existing pathogens or diseases and pests which were of minor importance in the past, are becoming important now. If the rust epidemics as we experienced in 1946-47 in Central India and 1956-57 in eastern India occur again our whole production would be upset. All the present commercial wheats of India like Kalyansona, Sonalika, Sharbati Sonora, Chhoti Lerma, Safed Lerma, Lal Bahadur, Hira, UP 301 have become susceptible to one or the other of the major diseases. Unless these varieties are replaced quickly by better disease resistant varieties we would be heading towards catastrophe. It is not only releasing just resistant varieties but they must have diversified resistance. An efficient disease precasting system is also needed so that farmers could take timely protection measures to save their crops from epidemics.

Nearly half of the wheat area of the country is grown under conditions of scanty rainfall or with no assured water supply. The yields here are extremely low. The wheat revolution is so far restricted to areas where assured water supply is available. Unless wheat yields are increased in the rainfed areas or alternative more remunerative crops are grown in these areas the situation would lead to social inequalities in the society. The wheat yields in the rainfed areas have to be increased through suitable agronomy (this is immediately possible), through suitable crop protection measures (for controlling white ants, stem borers, cut worms, spider mites) or through development of varieties which are drought resistant. Triticales, which are developed through crossing of rye with wheat may be one of the possibilities for successfully growing under deficient moisture conditions.

The wheat revolution in India has met so far the quantitative needs of this important cereal in the country. The nutritive quality, through higher protein and more balanced essential amino acids like lysine, tryptophane etc., has to be improved to help the health of the weaker sections of the society who mainly depend on this cereal. There is a great demand by the bread, biscuit and confectionary industries of the country for special wheat varieties with varying gluten qualities and protein contents. With the stoppage of imports of wheat suitable for bread making purposes, the bakeries in India have to rely on indigenous wheats which are to be grown on large scale now, to meet their demands.

At present large quantities of wheat is lost in harvesting, threshing, transportation and storage. Efficient post-harvest technology is an urgent need of the day not only to reduce the losses but also to reduce the prices.

Machinery suitable for seeding, fertilising, harvesting and threshing is increasingly felt to improve the efficiency of farm operations. A number of such implements and machines are already being manufactured in India but they are beyond the reach of the small farmers. In the light of land ceilings, machinery suitable for small holdings are to be urgently developed.

Micronutrients

For the first time Indian soils are facing the problem of micronutrients. The need of major nutrients like nitrogen, phosphorus and potash is met by the fertilizers now manufactured in India or imported from other countries. The high yielding varieties are depleting the soil rapidly of the micronutrients like Zinc which, unless suitably replaced would adversely effect the yields. Wheat crop in the terai area of Uttar Pradesh, in Punjab and certain other states is already being effected by Zinc deficiency. Some of the high yielding varieties like Kalyansona which today occupy large areas in the country were found to be very susceptible to Zinc deficiency. Unless the micronutrients are applied along with the major nutrient elements the production of wheat would be adversely effected in the not too distant future.

Since we have reached a stage of surplus naturally we are thinking in terms of exporting wheat to other countries. At present the cost of Indian wheat is prohibitively high to compete in the international markets. For example the prices quoted on 18th June 1971 in Chicago (U.S.A.) and Winnipeg (Canada) per one bushel of wheat, were $162\frac{1}{2}$ and $180\frac{7}{8}$ cents, respectively. This comes to Rs. 44.68 and Rs. 48.38 respectively per quintal. Unless the production, handling, transportation, warehousing and other charges are reduced it would be difficult for us to compete in the international markets with the prevailing wheat prices in the country. However, there is scope now for export of *durum* (macaroni) wheat and special wheat products.

In retrospect it could be said tha the wheat revolution has sparked off the green revolution in general in the country. It greatly helped the economy of the country. It reduced our dependence on foreign countries. It acted as a catalyst in influencing the cropping patterns and attitudes of farmers and policy makers. It convinced the farmers of the benefits of new scientific technology. Finally it gave us more confidence to plan our own policies and destiny.

Absorb the

Know-how

of the

Green Revolution !

Read

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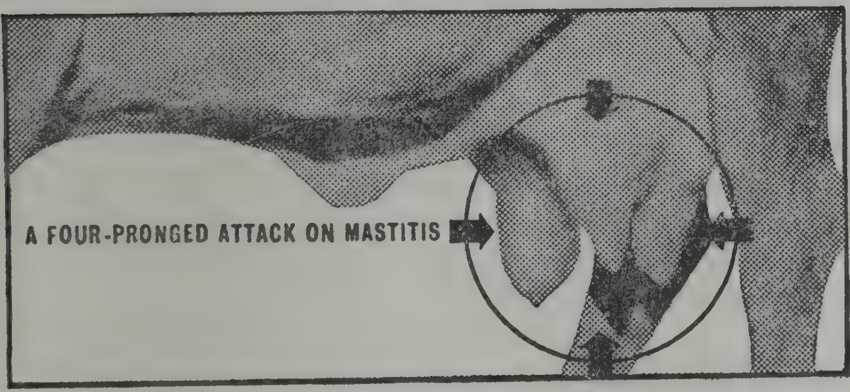
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PV.G.58.(A)

GREEN REVOLUTION ON DRY LANDS

Co-ordinator's Cell, All India Coordinated Research
Project for Dryland Agriculture Hyderabad

We made agricultural history during the late 60s by ushering in the era of 'green revolution' on our irrigated lands. In its wake, however, also developed some socio-economic imbalances causing as much concern as the food gap in the recent past. Further, 42 per cent of the nation's food still comes from the area commonly termed as 'dry lands' whereon production is highly unstable and can seriously jeopardise our food supply and general economy in any year.

A shadow of despondency looms large and wide over vast tracts of our good arable lands in as many as 84 districts of the Union—about 47 m.ha or nearly 36 per cent of the net area sown, mostly in Tamil Nadu, Mysore, Orissa, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan, Haryana and Punjab. In these regions agricultural production is wholly dictated by the wayward monsoonal rains which are not only meagre (400 to 1,000 mm annually) but also extremely erratic as to their onset, amount, frequency duration and cessation. Crop production truly remains a gamble in the rains, woefully low and highly precarious. Poverty is writ large in the lives of the farming community. We can not make the monsoons behave or co-operate the way we desire but we can learn to live with them. It involves needed adjustments in the management practices on these lands calling for special attention to appropriate tillage, selection of the most adapted crops and their varieties, adequate use of fertilizers and adoption of satisfactory plant protection measures. Any weak link in this chain drastically pulls down production on these lands.

We are not new entrants to the 'art' and 'science' of crop production on the dry lands. Several independent research programmes on these lands were initiated as early as the 3rd and 4th decades of the present century. These efforts and, lately, the work of the Soil Conservation Centres yielded valuable results but failed to enthuse the farming community for want of a synergistic package programme.

The evolution of high-yielding short-term varieties of crops again revived keen interest in the possibility and feasibility of upgrading and updating crop production in dry farming regions of the country.

In June, 1970 a comprehensive All India Coordinated Research Project on Dryland Agriculture was sanctioned in collaboration with the Government of Canada. 24 Centres representing different agro-climatic and soil zones are participating in the Project manned by 225 Indian scientists and 5 Canadian Experts. The Project is now well set for conducting a continuous comprehensive research programme for a quick and substantial enhancement of production and income potential of these lands. Results of two crop season are already available from many Centres and suggest that these lands can also be managed to yield handsome gains.

Relative Moisture Use Efficiency

Many crops and their varieties are being tested for their efficiency in using rainfall and stored soil moisture at different stations. The average yield data of the crops tested are presented in Table 1 next page.

It is apparent from the Table that under the given rainfall and soil conditions in a particular region some crops are more adapted than others. For instance, the wheat crop yields very well on dry lands at Ludhiana, Indore, and Agra but gives poor performance in Hissar, Bijapur and Sholapur. Gram seems to be a very adapted crop for Varanasi, Agra and Indore while mustard did well at Agra and Hissar. An idea of the suitability of a crop relative to others could be had from the above table for any Centre. In the kharif season maize was found to be a very good yielder at Indore, Udaipur and Ludhiana. For Indore, jowar is another profitable crop. Bajra seems to be well-adapted in regions represented by Samba, Ludhiana, Rajkot, Agra and Hebbal. The pulse crops yielded very low in almost all the locations, while ragi is well-suited to the climate and soil of Hebbal. Groundnut performed well at Ludhiana, Rajkot, Hebbal and Indore only. The castor crop gave high performance at Hyderabad.

Varietal Performance

It is not only the crops that exhibit varying adaptability at different locations, their varieties also yield substantial differences at the same location. The varietal differences in the performance are very well brought out in Table-2.

variety HB-3 gave as much yield as 36·7 q/ha while the local variety in common use produced as little as 14·7 q/ha. Another striking observation may be made in

TABLE 1. AVERAGE CROP YIELD IN Q/HA

Centre	*Jowar*	*Wheat*	*Barley*	*Gram*	*Mustard*	*Linseed*	*Safflow*	*Lathyrus*	*Lentil*
Rabi									
Ludhiana	—	19.0	—	—	—	—	—	—	—
Hissar	—	3.2	28.2	13.4	16.1	—	—	—	—
Agra	—	13.0	23.2	16.8	20.8	12.0	—	—	—
Varanasi	—	8.6	11.6	28.6	6.5	14.2	14.3	25.5	15.5
Rewa	—	—	15.1	9.1	—	—	—	—	—
Indore	—	20.4	—	14.5	—	9.1	15.3	—	—
Bijapur	—	5.6	—	9.1	—	5.3	12.3	—	—
Sholapur	3.9	3.0	—	7.3	—	—	5.1	—	—
Bellary	11.5	—	—	—	—	—	9.1	—	—

Centre	*Maize*	*Jowar*	*Bajra*	*Urd*	*Mung*	*Til*	*Ragi*	*G. nut*	*Cow-pea*	*Sesa-mum*	*Sunflo-wer*	*Castor*
Kharif												
Varanasi	17.7	2.1	13.2	7.8	2.8	4.8	—	—	—	—	—	—
Hebbal	—	—	17.2	—	—	—	23.3	13.3	—	—	—	—
Agra	—	—	18.6	—	—	—	—	—	—	1.8	6.6	—
Samba	22.4	—	29.7	—	3.3	—	—	5.0	—	—	—	—
Bijapur	—	—	5.6	1.7	1.6	—	—	—	—	—	—	9.6
Ludhiana	32.7	—	24.3	12.6	—	—	—	19.8	—	—	—	—
Udaipur	26.8	16.9	—	—	—	—	—	8.2	—	—	—	—
Akola	—	9.4	6.4	—	—	—	—	9.7	—	—	—	—
Rajkot	—	14.9	21.0	—	—	4.8	—	13.2	—	—	—	—
Hyderabad	—	—	8.8	—	—	1.6	—	3.3	11.8	—	—	25.2
Indore	39.1	22.9	—	—	7.9	—	—	11.1	—	—	7.2	—
Hissar	—	—	13.0	—	3.3	—	—	—	—	—	—	—
Jodhpur	—	—	9.5	—	5.2	—	—	—	—	—	—	2.4
Anand	—	—	17.4	—	1.9	—	—	—	—	—	—	—

The yield differences between the varieties of the same crop at different locations are very obvious in Table 2. At Varanasi, maize variety G-5 yielded 24 q/ha while the local variety produced only about 11 q/ha. Similarly, at the same station urad variety T-9 yielded over 11 q/ha while the common local green-gram produced hardly 3 q/ha. While great varietal yield differences are apparent in the above Table we may consider bajra production at Ludhiana. The new respect of groundnut at the same Centre. While the variety M-13 of groundnut produced almost 31 q/ha, the variety M-145 gave as little as 14·3 q/ha.

Fertilizer Use For Dryland Crops

Until recently lack of a profitable response of crops to fertilizer applications on the dry lands was the most despairing feature of production. This was so mainly because the crops were of long duration and had to

TABLE 2. AVERAGE YIELD (Q/HA) OF DIFFERENT CROP VARIETIES

Centre	*Crop*	*Variety*	*Yield (q/ha)*
Varanasi	Maize	G-5	24.0
		Kisan composite	17.1
		Local	11.9
	Urd	T-9	11.4
		Local (black)	9.2
		Local (Green)	2.8
Hebbal	Ragi	Sharda	27.5
		Purna	23.1
		Local	19.4
Ludhiana	Bajra	HB-3	36.7
		S-536	21.3
		Local	14.7
	Groundnut	M-13	30.9
		C-148	18.5
		M-145	14.3
Rajkot	Jowar	Swarna	20.8
		CSH-1	19.5
		CSH-3	4.4
Hyderabad	Cowpea	Russian giant	16.4
		T-2	13.5
		EC-4216	5.6
Indore	Soybean	J-231	33.3
		Clark-63	25.9
		Bragg	17.0

to often pass through periods of extreme moisture stress which inevitably vitiated the effects of all yield-boosting inputs applied. Also the old crops/varieties were not quite efficient, genetically, to benefit highly from applied inputs. The situation has not changed and the results obtained show that up to a point fertilizer use on drylands is highly profitable. Table 3 supports this contention.

As may be observed in the Table crops benefited substantially from nitrogen applications at many places. At Ludhiana, the wheat crop showed a linear response to nitrogen up to 120 kg/ha. The yield increased from 8·5 to 26·3 q/ha. At Rewa a similar gain was observed. Barley showed no gain at Hissar. At Agra this crop benefited only from high applications. In the kharif season the gains at most places were more pronounced in respect of bajra., jowar, rice and maize. At Anantapur the yield of bajra increased from 4·8 to 26·5 q/ha. The yield of rice at Rewa, similarly, went up from 12·4 to 32·6 q/ha. The response of maize at Ludhiana was striking from 7·0 to 39·4 q/ha.

The results of P application to crops have been encouraging only at few places. For instance at Banglore the yield of finger millet increased from 6·6 q/ha (no phosphate) to 16·6 q/ha and 25·6 q/ha with the application of P_2O_5 at 25 and 50 kg/ha respectively, over a basal application nitrogen at 50 kg/ha.

At most of the Centres no material differences in yield could be found between basal soil application of nitrogen and soil+foliar application of the nutrient.

Project Research Programme

A comprehensive research programme embracing all important crops of the dryland regions is in hand. Briefly, this encompasses:

1. Testing crops nd their varieties for their relative efficiency in using rainfall and stored soil moisture.
2. Evolving crop sequences in regions where possible to yield high stable incomes per annum.
3. Evaluating crop misxures using non-traditional methods of planting and fertilization.
4. Estimating optimal crop densities (population) to suit crop and soil conditions.
5. Assessing techniques and materials for increasing the rate of water intake in soils, where problems exist, to reduce runoff and better recharge.
6. Studying effects of soil compaction for better germination and channelising rainfall.
7. Using mulches to reduce evaporation and maintain better soil surface for absorption of rain.
8. Estimating crop responses to fertilizer applications.
9. Harvesting and storing surplus water for use as 'protective' irrigation in critical periods.
10. Screening crops and varieties for their adaptability in different regions of the country.

TABLE-3. YIELD DATA (Q/HA) FROM EXPERIMENTS ON APPLICATION OF NITROGEN AT VARYING LEVELS

Centre	*Crop*	N_0	N_1	N_2	N_3	N_4	*CD*	*Nitrogen levels (kg/ha)*
A. **Rabi**								
Ludhiana	Wheat	8.5	17.2	21.2	26.3	—	4.3	(0,40,80 & 120)
Hissar	Barley	16.8	17.6	21.1	18.2	—	—	(0,20,40 & 60)
Agra	Wheat	7.2	8.0	8.5	7.5	—	0.9	(0,20,40 & 60)
	Barley	25.0	25.7	29.0	32.1	—	0.9	(0,20,40 & 60)
Varanasi	Wheat	9.5	11.6	10.1	14.1	15.0	—	(0,20,40,60 & 80)
Rewa	Wheat	3.7	9.0	13.5	14.8	—	—	(0,20,40 & 60)
Indore	Wheat	10.6	12.1	14.8	15.8	—	3.5	(0,20,40, & 60)
Anand	Wheat	5.6	6.5	7.6	8.1	8.2	2.0	(0,20,40,60 & 80)
Sholapur	Jowar	4.8	7.7	8.6	—	—	2.2	(0,25 & 50)
Bellary	Jowar	8.3	9.8	8.1	9.1	8.9	—	(0,20,40,60 & 80)

Centre	*Crop*	N_0	N_{40}	N_{80}	N_{120}	*C.D.*
Kharif						
Rajkot	Bajra (HB-3)	13.0	18.0	**23.9**	25.1	3.7
Udaipur	Jowar (swarna)	7.1	10.1	**13.5**	19.6	5.1
Bangalore	Ragi (sharada)	16.0	16.9	19.0	20.8	—
Anantapur	Bajra HB-3	5.1	13.1	18.6	21.5	3.4
Hyderabad	Bajra (all entries)	10.9	17.0	15.7	16.2	0.4
Rewa	Rice (Bala)	12.4	18.6	28.7	32.6	2.9
Anand	Bajra (HB-3)	4.8	14.4	24.1	26.5	4.0
Hissar	Bajra (HB-3)	16.0	21.1	26.8	29.5	0.15
Jodhpur	Bajra (HB-3)	7.2	10.5	11.0	10.2	2.8
Ludhiana	Maize (Ganga-5)	7.0	17.3	27.4	39.4	11.4
Varanasi	Rice (Bala)	10.9	16.3	18.3	20.6	4.2

Some Recommendations

During the past two seasons some results of practical importance were achieved.

1. Bajra HB-3 yielded 32% higher than bajra HB-1. Averaged over 8 locations the mean yields were 13·8 and 10·5 q/ha, respectively.

2. Jowar CSH-1 outyielded 'swarna' by 29%. The average yields of four Centres were 19·0 and 14·7 q/ha, respectively.

3. Limited data show that Jaya, CR-44-1, Krishna and Kaveri yield well as drilled upland rice (more than 25 q/ha).

4. Cowpea C-152 gave an outstanding yield performance at almost all Centres where it was tried (12·7 q/ha).

5. Sunflower has done well uniformly. At six locations the yield averaged 8·2 q/ha. It has many advantages over other oilseeds including groundnut.

6. Bajra and rice respond economically up to 80 k/ha of nitrogen.

7. Advancing the date of sowing of rabi crops at Bellary, Bijapur and Sholapur results in higher yields.

8. There are indications that sowing of upland rice at Bhubaneswar, Ranchi, Dehra Dun, Varanasi and Rewa in anticipation of monsoonal rains is possible using slightly longer duration varieties having higher yield potential.

PANORAMA OF PROGRESS OVER A QUARTER CENTURY

Central Potato Research Institute, Simla. Constituted in 1949, the Institute directs research on this important crop, a valuable supplement to the diet of the poor and the rich alike.

An experimental field in the Jullunder sub-station of the Institute—single plant hills of Kufri Sindhuri for production of virus free potato.

Simple fertilizer trials in farmers' fields were initiated in 1953. The significant programme gathered momentum and the All India Co-ordinated Agronomic Experiments Scheme followed a little later. In the picture is found the difference between low P status soil and high P status soil.

Fertilizer makes all the difference—a photo study of Jowar (rabi) from the Model Agronomic Centre at Bhawanisagar.

NPK trials, a study from Hyderabad

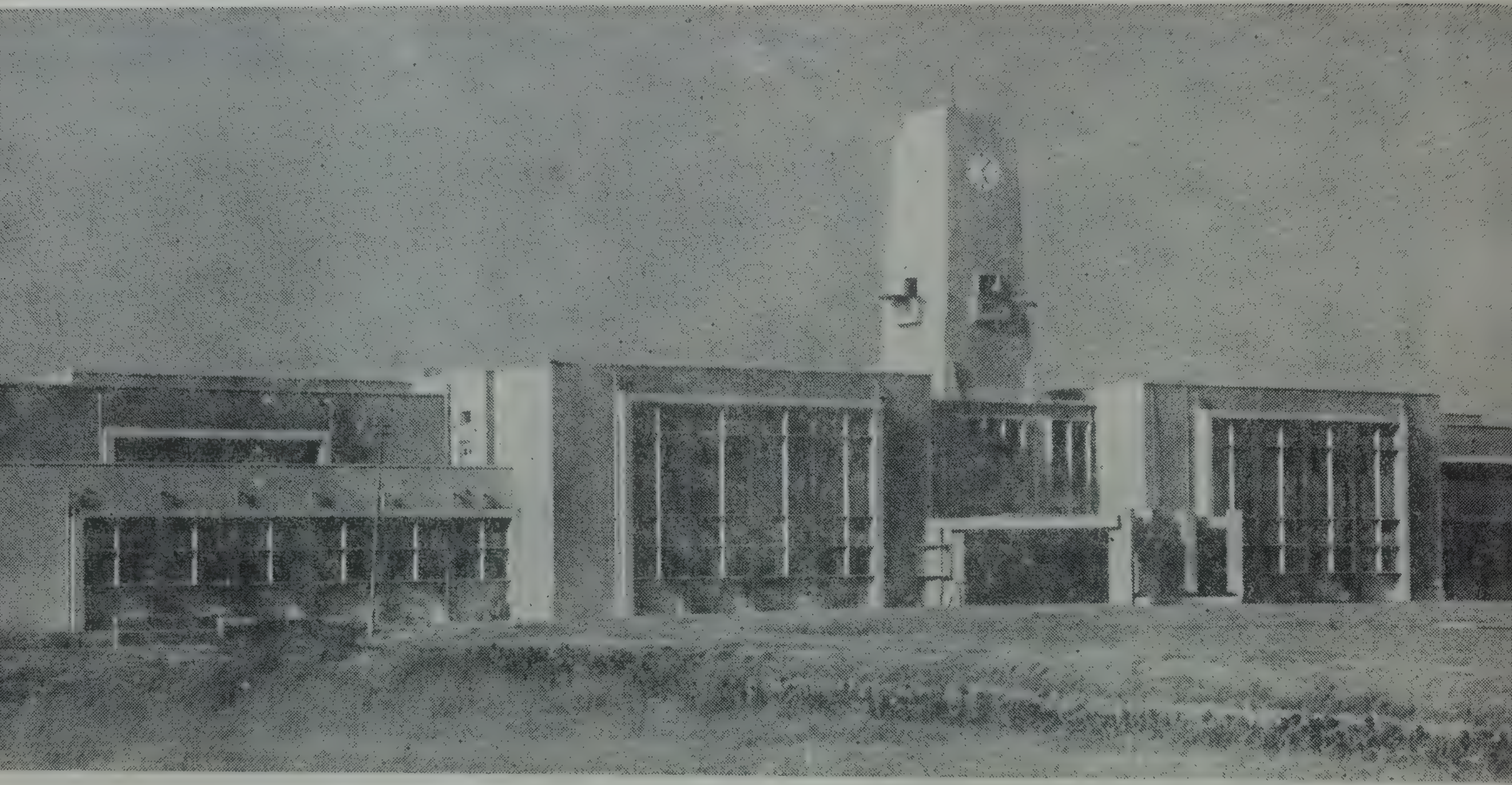
A scheme for Soil Conservation Research and Training Centres was initiated in 1954. Photo shows run off measuring set up at the Centre in Ootacamund.

Soil conservation programme—Hyderabad

Soil testing, again one of the important components of the overall agronomic programme. Picture shows a mobile soil testing laboratory at work in a village.

Soil testing laboratory at the Indian Agricultural Research Institute, New Delhi.

The momentous All India Coordinated Maize Breeding Scheme was initiated in 1957. The picture shows (top right) opaque-2 maize, rich in protein, (top left) the Kisan Composite and (below) a farmer in his Ganga-101 maize field.



Agricultural education, the thematic content of the new rural civilization Photo above shows the U.P. Agricultural University at Pantnagar, one of the earliest, and (right) the late Prime Minister Pandit Jawaharlal Nehru conferring degrees at one of the early convocations of the Post Graduate School, IARI, New Delhi. The P.G. School was established in 1958.

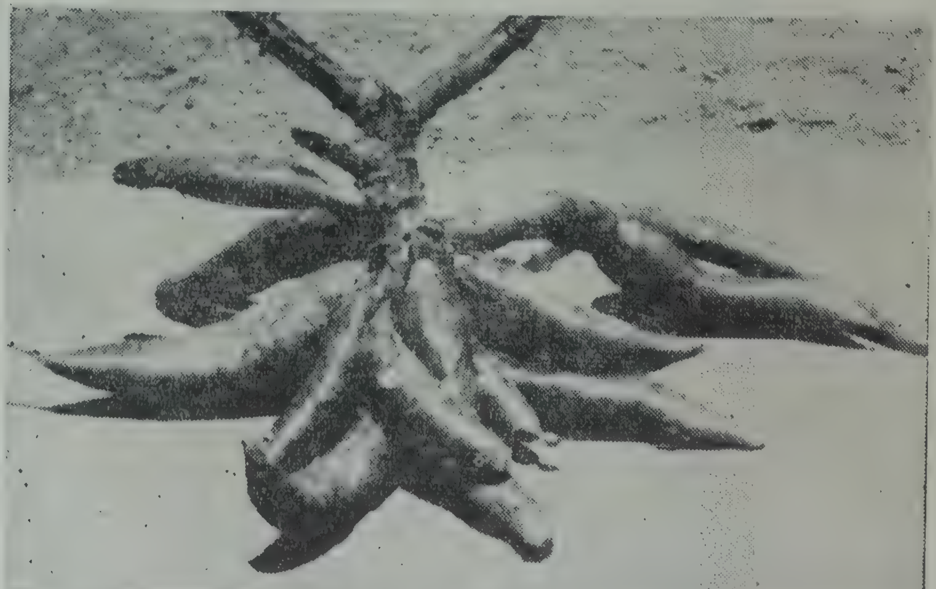
Gamma Garden at IARI, yet another milestone (1959)

Another important project, the Sorghum Improvement Scheme was launched in 1961. The pictures show CSH-1 and CSH-2.

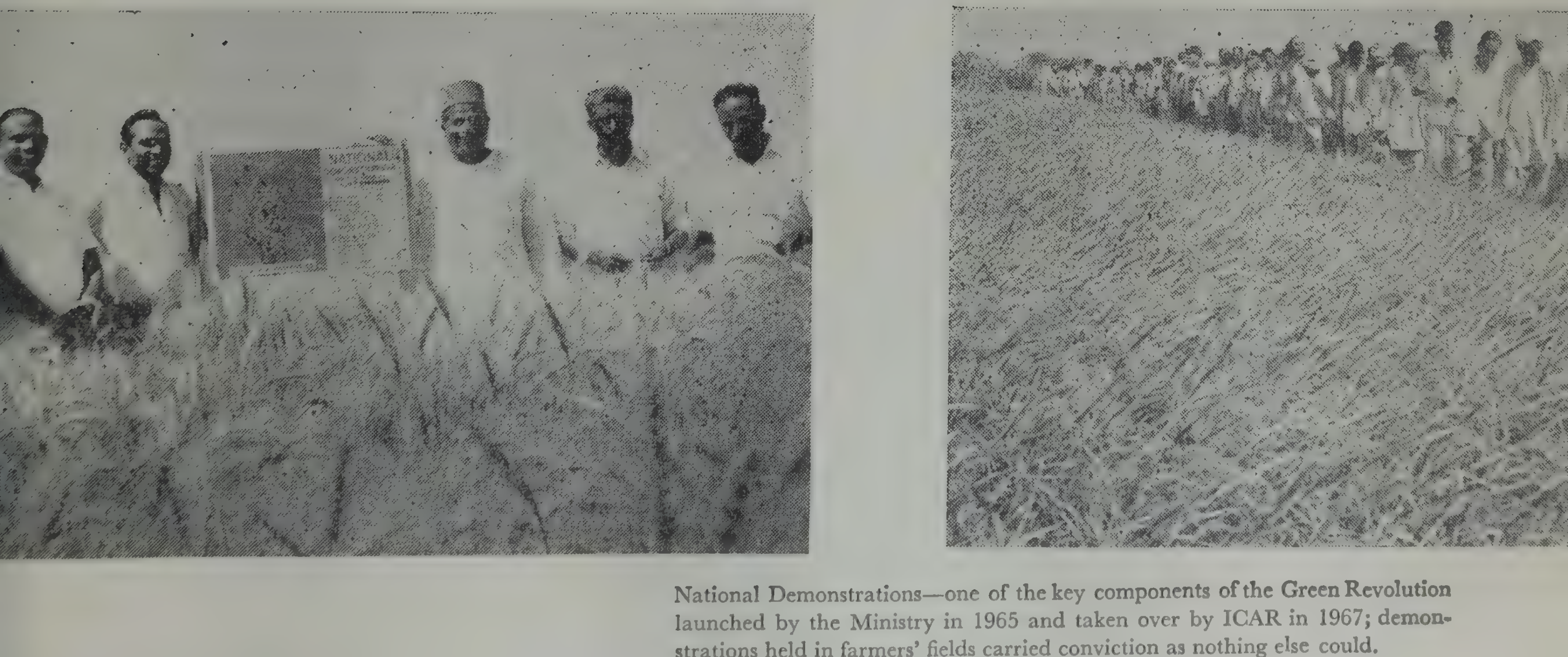
Sorghum Swarna, the high-yielder

CSH-3

The Central Tuber Crops Research Institute was set up at Trivandurm in 1963. Picture shows the high-yielding tapioca evolved at the Institute.



Hybrid Bajra-1, a high-yielder was released in 1965.

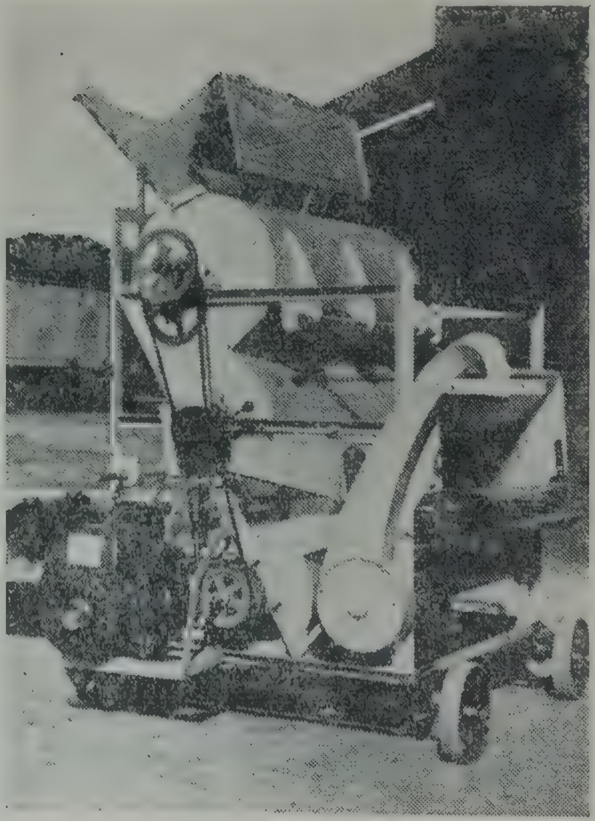


National Demonstrations—one of the key components of the Green Revolution launched by the Ministry in 1965 and taken over by ICAR in 1967; demonstrations held in farmers' fields carried conviction as nothing else could.

20 P
INDIA
WHEAT REVOLUTION

Another great occasion. The Wheat Revolution stamp was released by the Prime Minister in 1968.

Kalyansona, the great dwarf wheat that brought us hope and confidence, released in 1967.



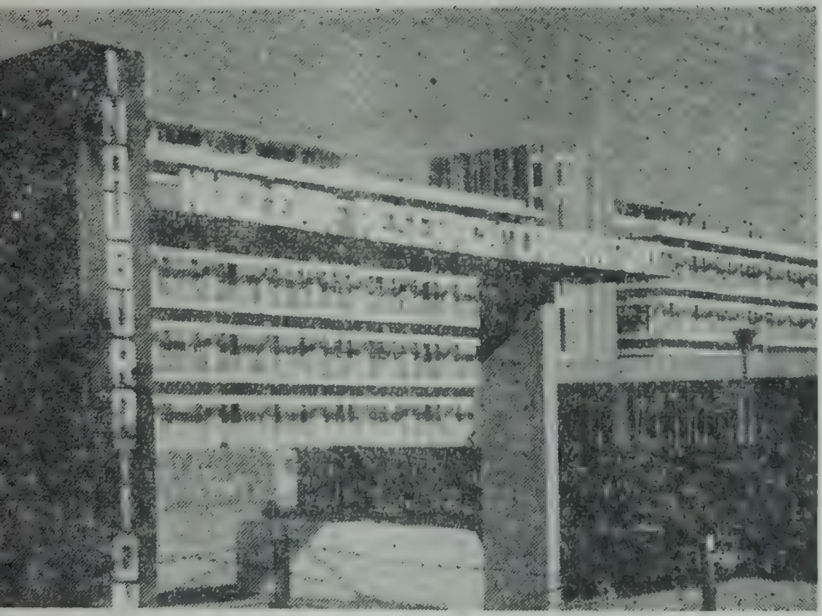
Pusa-40 Thresher (1968)

On step to a rice revolution—IR-8.

Jaya, the high-yielding rice variety was released in 1968.

Indian Horticultural Research Institute, set up at Bangalore in 1968 was yet another milestone. Nutritional vegetables at an exhibition.

(Left) Hira, the triple-gene dwarf wheat was released in 1970 and (top) sunflower crop.



The Nuclear Research Laboratory was opened at IARI, New Delhi by the Prime Minister in 1970.

Sheep assembled in Kashmir for being administered with a radiation-attenuated vaccine against lungworm infection produced at IVRI, Izatnagar.

The forage crop programme received a further boost with the initiation of a Co-ordinated Project.

The All India Co-ordinated Research Project on Dryland Agriculture, sanctioned in 1970, gave fillip to the already existing efforts. Picture shows an experimental field on dryland crops at IARI.

Dusheri × Neelum, the new mango at IARI, New Delhi

Cotton 'Sujata', the first Egyptian type of cotton released in India in 1969

150
125
75
50
25

A promising arecanut hybrid at Vittal

LOCAL INDO II
1059 (VTL 48
14 PLANTS

Tall × Dwarf hybrid coconut at the Central Plantation Crops Research Institute, Kasaragod.

White Leghorn, one of the prize birds at a Livestock Show, Hissar.

Sahiwal X Brown Swiss cross-bred cow

Signing of the Constitution of the International Crop Research Institute for the Semi-arid Tropics, Hyderabad—R.H. Demuth on behalf of the International Bank for Reconstruction and Development and Dr. D.L. Umali, Assistant Director-General, F.A.O.

FISH TECHNOLOGICAL EXPERIMENTAL STATION
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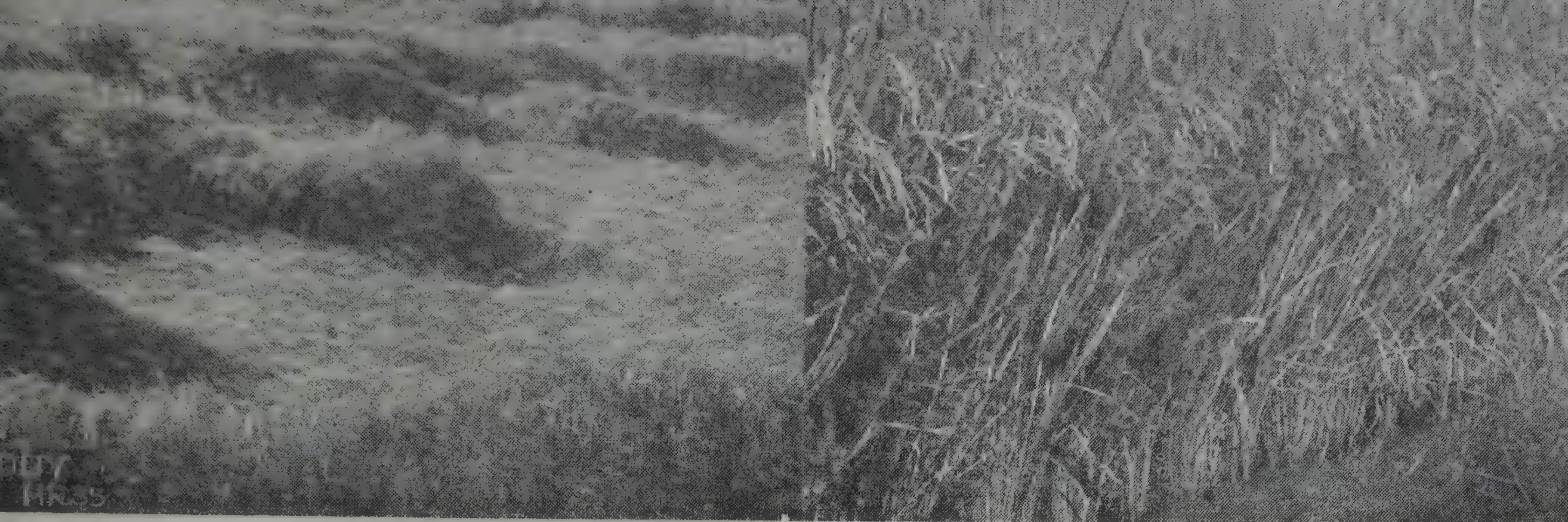

Then and now! Tall traditional varieties lodged at flowering (left) HR 35, while the new dwarf varieties (right) IET 1919 stay erect up to harvest. (Fig. 16)

TOWARD A RICE REVOLUTION

S.V.S. SHASTRY

Project Co-ordinator, All India Co-ordinated Rice Improvement Project, Rajendranagar, Hyderabad-30 A.P.

THE rice situation in India looked alarming at the time India attained independence. Increasing population, economic backwardness of rice farmers, scattered and small holdings, poor water control and excessive reliance on monsoon, low production and consumption of fertilizers and poorly organized agricultural services—all contributed to the dismal picture leaving little room for optimism in stepping up production of the major staple food of the Indian population.

Major decisions taken by the Government of India over the last 25 years relating to increased irrigation facilities, commissioning of fertilizer and other agro-chemical plants and strengthening of research education and extension in agriculture, however, brought an altogether new life into the rice system. As a result of these investments and decisions, rice production in India has now been nearly doubled from a base level of 22 million tons in 1947. While this is no humble achievement, the potentials and opportunities to increase rice production are even greater. Big gains are expected in the next few years resulting in a major breakthrough in production, parallel to that which has occurred in wheat.

The Fifties

The Central Rice Research Institute (CRRI), established in 1946 at Cuttack (Orissa), played a critical role in identifying the problems of national interest and giving specific emphasis on production-based problems. This institute enjoyed the valuable guidance by eminent scientists like Dr K. Ramiah and Dr N. Parthasarathy and maintained close contact with the International Rice Commission, set up in Organization of the United Nations. One of the significant contributions of the institute was to foresee the anticipated changes in Indian rice culture and to identify the deficiencies in local varieties.

The primary reason for low productivity of tropical rices has been attributed to low fertilizer responsiveness. An ambitious international cooperative project aimed at hybridization of fertilizer responsive *japonica* types with tropically adapted *indica* types was initiated at the CRRI in 1950 with the financial assistance from the FAO and the Indian Council of Agricultural Research (ICAR). This project ultimately led to the identification of two varieties—ADT 27 in India and Mahsuri in Malaysia—both of which contributed significantly to rice production in India. ADT 27 is early in maturity and fitted the Kuruvai season in Thanjavur delta making it possible to bring about the conversion of a good part of single cropped rice area in this district to double cropping. Mahsuri, on the other hand, proved to be particularly suited for the kharif season of coastal Andhra Pradesh, where it replaced traditional varieties. In spite of these gains, the project failed to fully achieve the objectives set for itself viz., the transfer of fertilizer responsiveness on the scales comparable to *japonica* types. Similarly, the

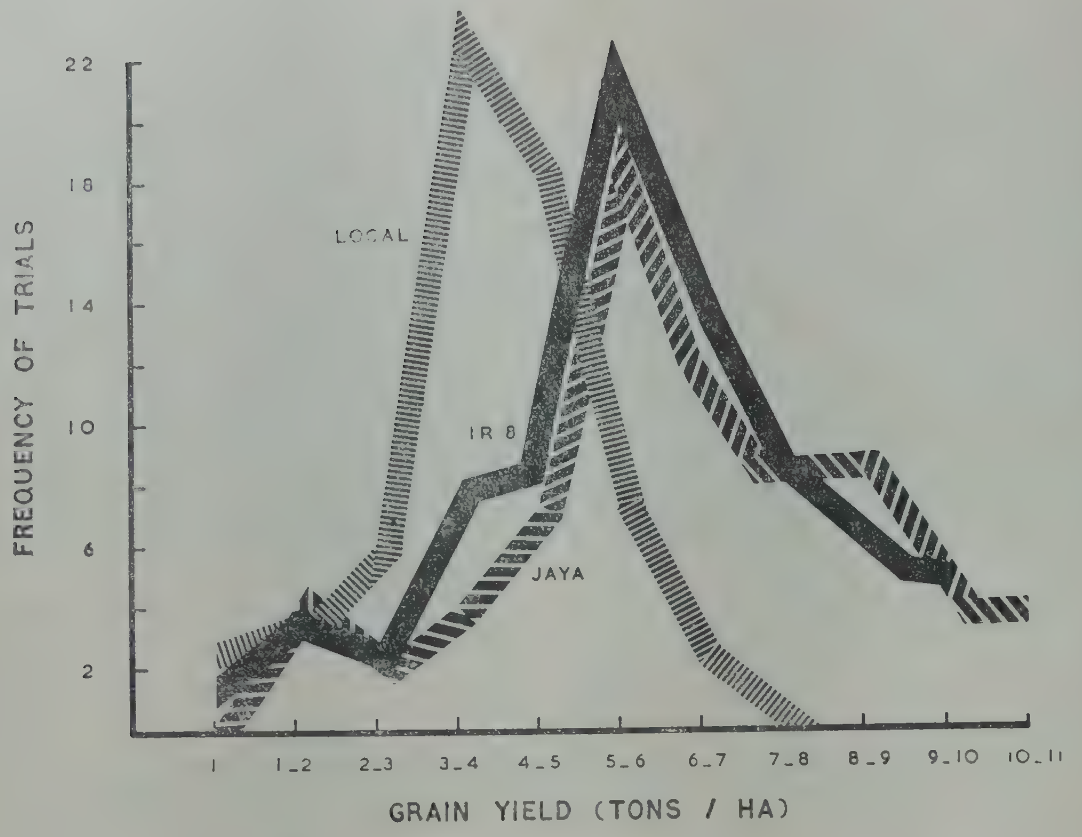

Fig.1. Jaya outperforms IR 8; both are highly superior to locals- District trial data, Punjab Kharif 1969

efforts to modernize agriculture by introduction of better cultural practices and popularization of fertilizers (so-called Japanese method of cultivation) met with limited success because of low nitrogen responsiveness of the tropical varieties which were then in vogue.

Early Sixties

Success in agricultural development depends on several factors, limitations imposed by any of which might affect the overall program. With this concept in mind, a program, referred as "Intensive Agricultural District Program" (IADP), was launched in 1961 with the primary goal of increasing the production in a compact area. The program envisaged concentrated efforts on agricultural extension together with intensification of inputs such as improved seeds, fertilizers and credit. In the early days of this program, visible increases in production were not secured, once again due to the limitations of the then existing tropical rice varieties. The infrastructure for development in this well-conceived program, however, paid rich dividends in later years when the High-Yielding Varieties program was introduced.

The introduction of the dwarf rice variety—Taichung (Native) 1—from Taiwan through the International Rice Research Institute (IRRI) in 1964, was a significant turning point in rice culture of India. The scientists and extension workers, for the first time, saw hopes in bringing about a quantum jump in rice production. This variety which typifies the plant type built into the recent high-yielding varieties of India, produced twice as high yields as the best local varieties, under good management conditions. Attendant with this hope was the reservation on the acceptance and scepticism on the suitability of a single variety over large diverse areas of the country; and even an apprehension of an escalation of pest-disease problems. Despite these reservations, Taichung (Native) 1 was released by 1965 for cultivation in specific areas of the country. The potentials and problems with the dwarf rice varieties called for an aggressive, imaginative and coordinated research program to evolve varieties with good plant type and yet provide a wide range of choices in duration, grain type and resistance to pests and diseases.

All-India Coordinated Rice Improvement Project (AICRIP)

The Indian Council of Agricultural Research approved in 1965, the initiation of the All-India Coordinated Rice Improvement Project with its headquarters at Hyderabad, Andhra Pradesh. The Rockefeller Foundation, the International Rice Research Institute and the U.S. Agency for International Development have been associated with the project. The coordinated program set the highest priority for the acceleration of breeding effort with the dwarf varieties with suitable grain type and resistance to pests and diseases so as to suit the diverse agroclimatic conditions of the country. Like other coordinated projects, the AICRIP maintained its multidisciplinary and multi-locational character.

With time, the AICRIP emerged as a major factor of cohesion in the national rice research effort. Communication among the scientists improved and a common, speedy and efficient testing program has been evolved. The pay off started with the release in 1966 (ahead of being named by IRRI, where this selection was developed) of IR. 8 and in 1968 of Jaya, which is even better in yield and earlier in maturity to IR. 8, a variety acclaimed as "Miracle rice of Asia". The acceptance of IR. 8 and Jaya by the Indian farmers was speedier and less controversial than that of Taichung (Native) 1. Further, in all locations where IR. 8 and Jaya were tested, the superiority of the latter was evident (Figs. 1 and 2) and Jaya has now exceeded the area planted to IR. 8.

The coordinated project which

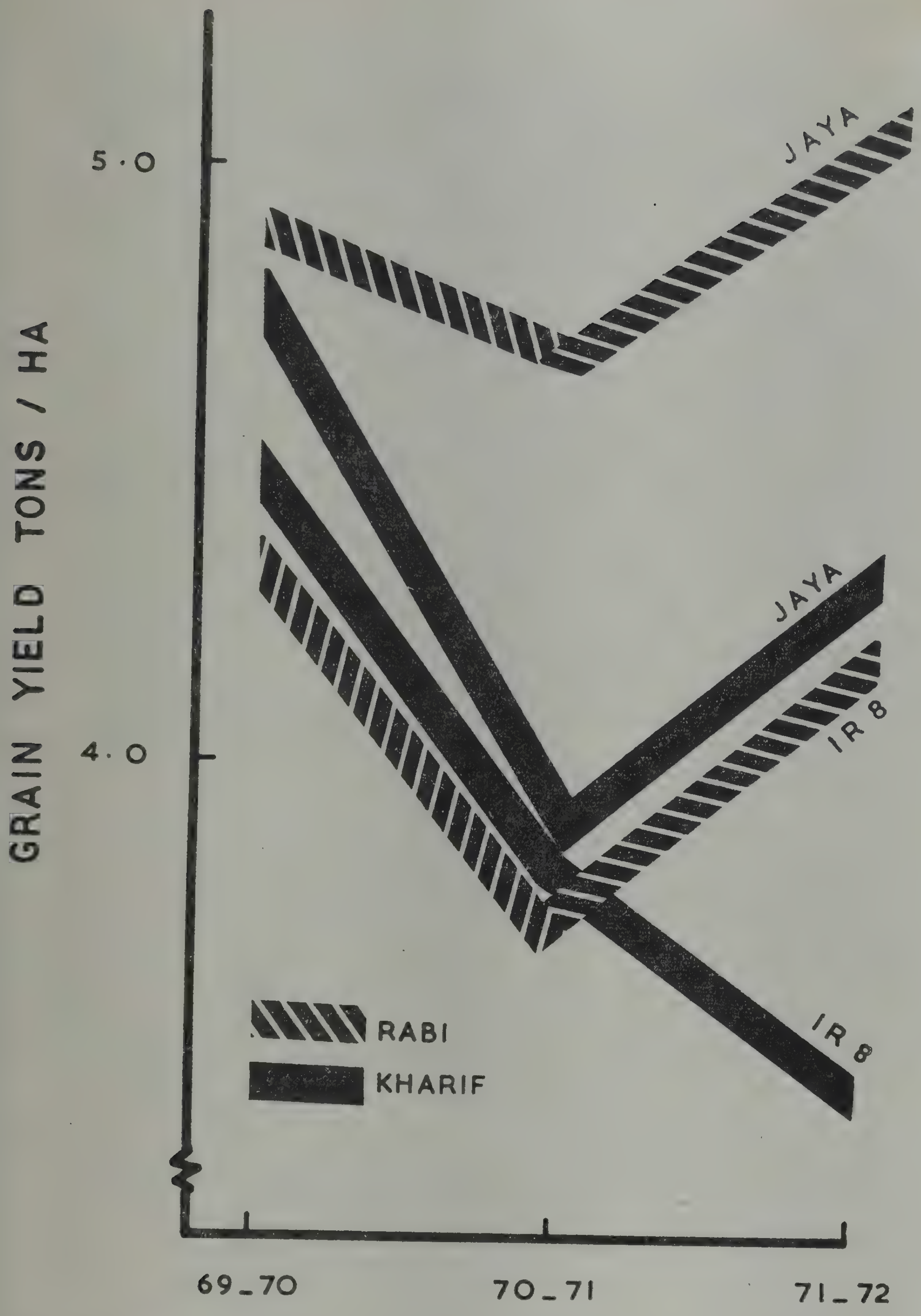

Fig. 2. Jaya outyields IR 8 in both kharif and rabi seasons crop-cut-experiments, West Godavari-Andhra Pradesh

symbolises the sum total of research effort in the country irrespective of institutional affiliations — central, state, university experimental stations, etc.—generates, tests and identifies material of value. The task of identifying regional suitabilities of these varieties is accomplished by adaptive research programs implemented by different state departments of agriculture and/or agricultural universities. Several prerelease variety trials have been organized between 1969-71. Tests of this type accelerated the spread of Jaya in Punjab and Haryana and Karuna in Tamil Nadu.

Dwarf plant type varieties are significantly better than the local tall varieties in nitrogen responsiveness and outyield the latter at all levels of management (Fig. 3). They give better outturn of grain per unit of fertilizer added. Presently available dwarf varieties are photoinsensitive and hence are widely adaptable in the plains. They tend to maintain good yields even when grown under a wide range of spacings (10×10 cm to 30×30 cm), due to compensation of performance in a community. Relative to management, their performance improves and thus they are management responsive. At the same time, they are more stable in production compared to the tall varieties.

Multi-location data on the performance of dwarf varieties lends itself to a detailed scrutiny on stability parameters and on yield potential. While dwarfs, as a class, exhibit better stability than the tall traditional varieties, some differences are discernible among the dwarfs (Fig. 4). Jaya exhibits high yield potential coupled with high degree of stability, being well above the mean response line under fluctuating management levels. Vijaya, with comparatively lower yield potential than Jaya, exhibits similar degree of stability. The varieties like CR 44-93 perform better than the mean only under top management conditions while others like C 9435 are better than the mean only under low management conditions. At the other extreme, varieties like CR 100—32 stay below the mean at all levels of management.

Overriding merits of dwarf plant types justified a complete reorientation of the breeding programs in different rice research stations in India in favour of dwarf varieties. A plethora of varieties with wide variation in maturity, grain type, yield potential and resistance to pests diseases have been developed between 1966-71. The Central Variety Release Committee released fourteen varieties for cultivation in several parts of the country; while even a

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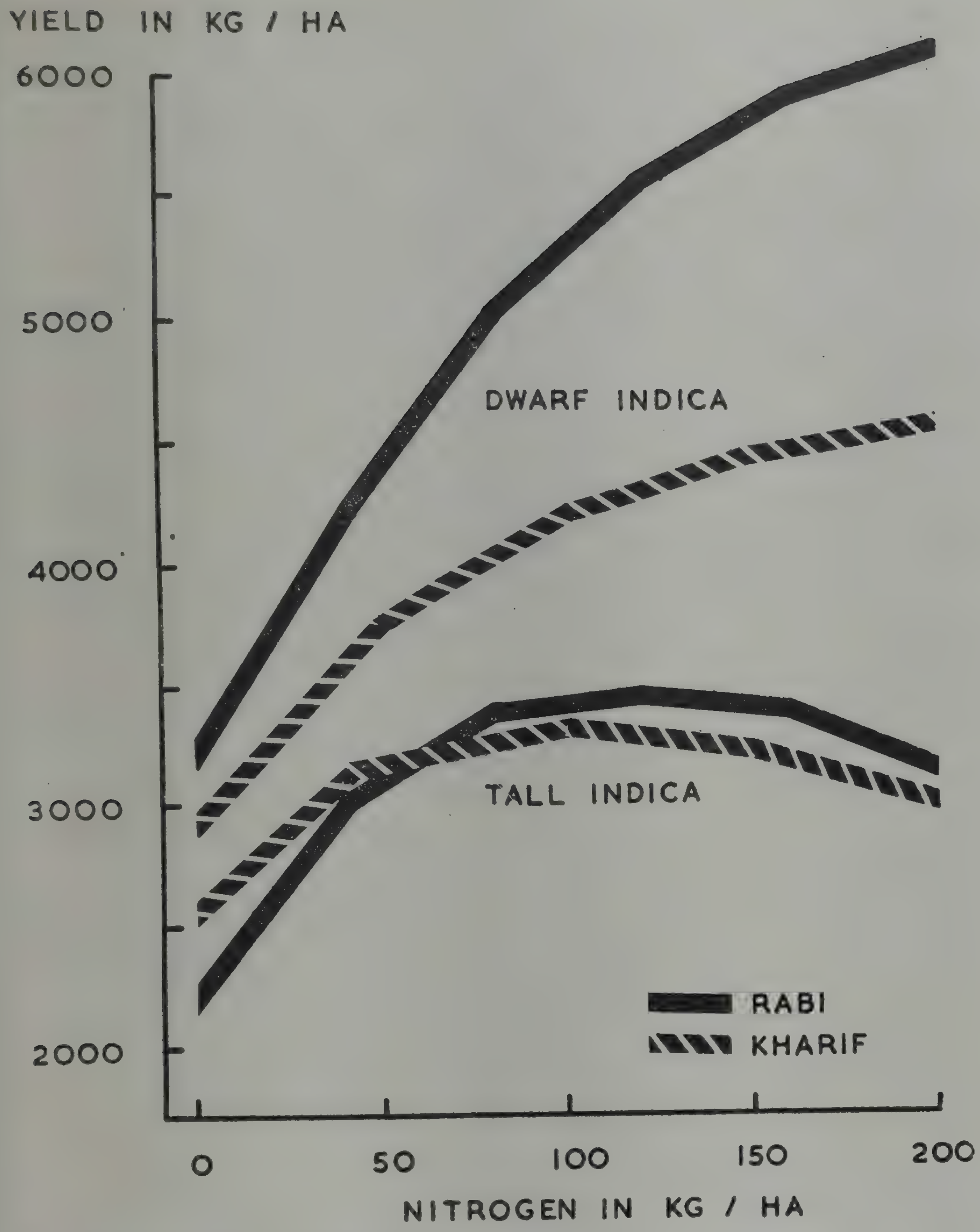


Fig.3. Dwarf *indica* varieties outperform local varieties at all levels of management (rates of N). Both dwarf and local varieties performed better in dry (rabi) season

larger number has been released by the State Release Committees for cultivation in limited localities. Several promising experimental lines have been identified by the AICRIP workshop for pre-release multiplication and on-the-farm testing and this group includes predominantly gall midge and tungro resistant varieties. The year 1972 is indeed critical to sort out a limited number of varieties which might have significant role to play in future increases of rice production. A few of such varieties with possible impact on future programs are listed in Table 1.

Environmental specification of a region helps in *ad hoc* choices of rice varieties for a particular locality. The duration of the variety that could safely be grown in a location, is now recognized to be the primary factor. Additional criteria are the prevalence of major pests and diseases in a locality and consumer preferences for grain type. Among the available dwarf varieties, those with the duration of 130—140 days exhibit by far the best yield potential compared to the earlier and the later maturing varieties (Fig. 5). It is therefore advisable to choose varieties of 130—140 days duration unless environmental conditions are overridingly unfavourable.

Fig.4. Dwarf varieties are in general more stable in performance over a wide range of management conditions. Yet, the dwarf varieties differ in both yield potential and stability.

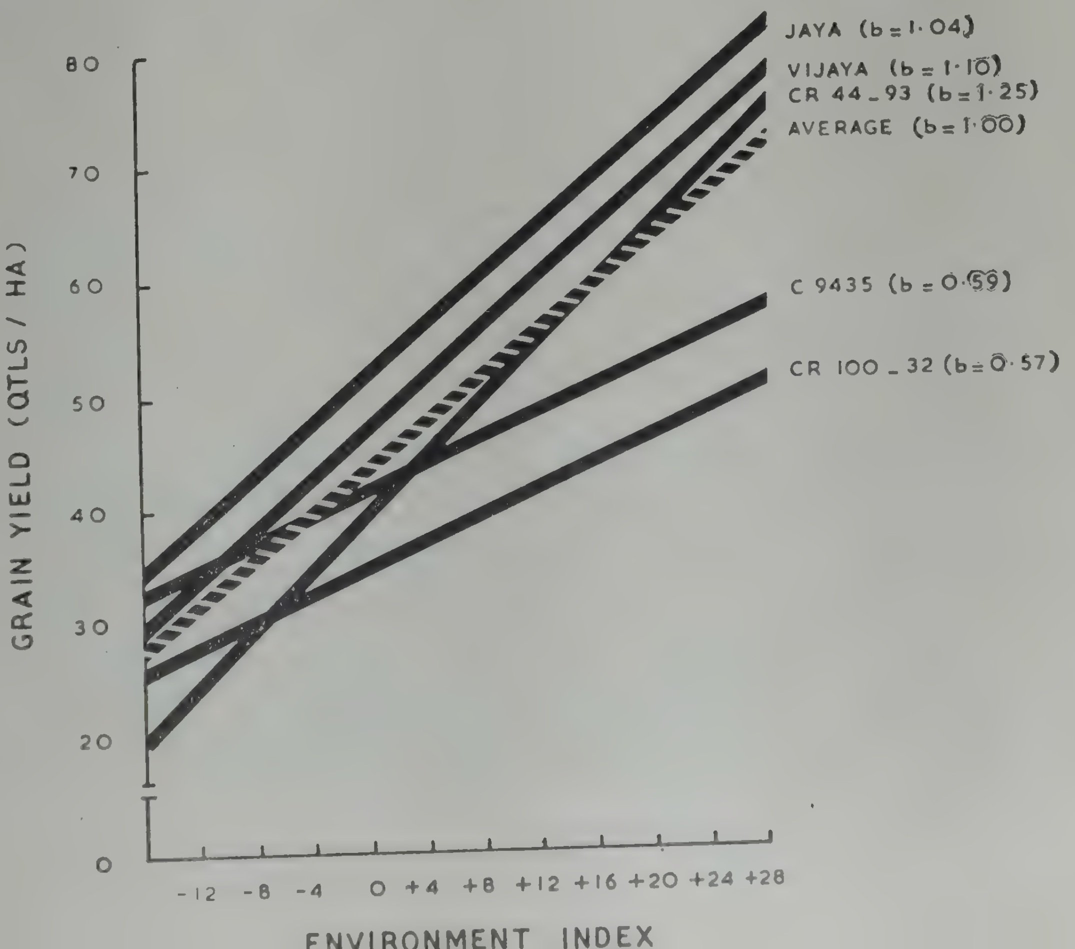


TABLE I. SALIENT FEATURES OF SOME PROMISING, PRE-RELEASE AND RELEASED VARIETIES IDENTIFIED BY THE COORDINATED PROGRAMME

A. Varieties released by CVRC		
Jaya	:	Medium duration; high yield potential and stability; blast resistant
Vijaya	:	Mid-late duration; moderate resistance to leafhoppers and tungro
Ratna	:	Mid-early duration; long slender grains; susceptible to blast and grain shattering
Cauvery	:	Early maturing; good tillering and yield potential; lodging susceptible
Bala	:	Early maturing; shy tillering; poor grain type
Jagannath	:	Long duration; heavy tillering; medium slender grains
B. Varieties released by State		
Karuna	:	(Tamil Nadu) Early maturing; round grains; BLB susceptible
Tella Hamsa	:	(Andhra Pradesh) Early maturing; long slender grains; tolerant to low temperatures at tillering
Palman 579	:	(Punjab) Mid-early duration; long slender grains; good yield potential
Annapurna	:	(Kerala) Early maturing; red kernels.
C. Pre-release varieties		
IET 1991	:	Medium duration; high yield potential; superfine grains; translucent kernels
IET 1039	:	Medium duration; good yield potential; long slender grains
Pusa 2-21	:	Early maturing; synchronous tillering; good yield potential; blast susceptible
CR 44-35	:	Mid-early duration; long slender grains
RP 107-1	:	Medium duration; compact tillering; extra—long slender grains with good elongation on cooking
RPW 6-12	:	Long duration; good tillering; long slender grains; resistant to gall midge
RPW 6-13	:	Long duration high yield potential; resistant to gall midge
RP 9-4	:	Medium duration; thick stem; compact tillering; resistant to gall midge and leaf folders
RP 260-228-1-1	:	Early maturing with grain dormancy; highly resistant to tungro and leafhoppers
RP 271-43-7-3	:	Early maturing; slender grains; highly resistant to tungro
RP 260-592-1	:	Mid-early duration; resistant to tungro; moderately resistant to leafhoppers and stem borer.
D. Experimental Materials		
RP 79-19	:	Early maturing with grain dormancy; medium slender grains
RP 5-46	:	Mid-early duration; very short stature; synchronous tillering; long slender grains
RP 5-37	:	Mid-early duration; good tillering; dense panicles; long slender grains
RP 5-59	:	Mid-early duration; high panicle number, long slender grains
RP 5-12	:	Long duration; good tillering; long slender grains
RP 5-32	:	Long duration; high yield potential, short bold grains
RP 176-4	:	Medium duration; heavy tillering, high yield potential
RP 176-6	:	Very long duration; good tillering and yield potential; tungro resistant
RP 193-1	:	Long duration; long slender grains
RP 31-49-2	:	Medium duration ; high yield potential, resistant to BLB and blast
RP 6-516-33-1-1	:	Medium duration; good tillering; resistant to stem borer
CR 110-174	:	Mid-early duration; good yield potential
CR 12-178	:	Mid-early duration; good tillering

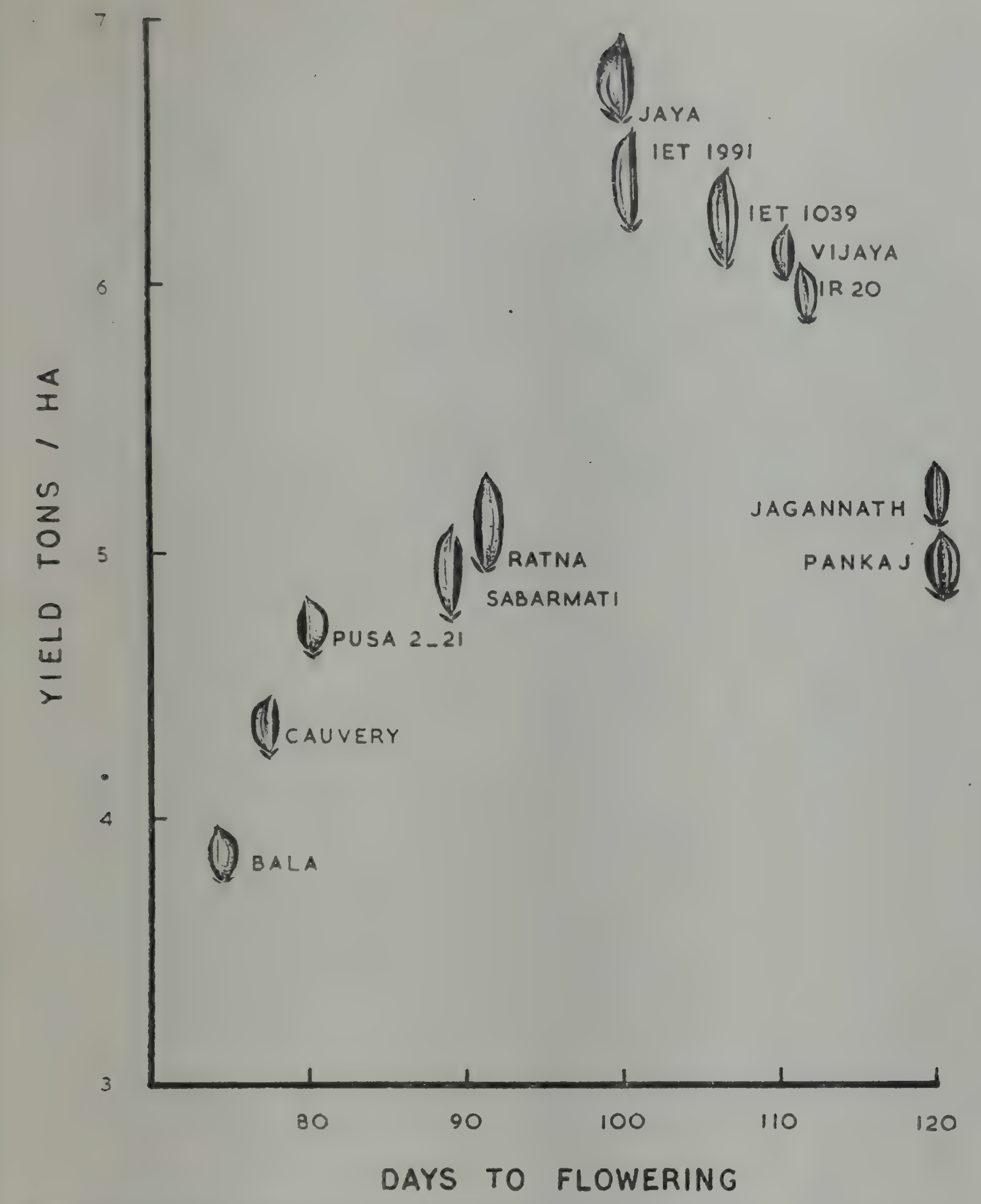


Fig.5. Among the presently available dwarf varieties those with total duration of 130-2S0 days have the highest yield potential, earlier and later varieties being lower in yield. Fine grain quality is not incompatible with high yield. (Schematic)

Breeding Techniques

Experiences gained in course of breeding dwarf varieties prompted the necessity to develop certain techniques to render the breeding procedures more effective. In the early days of dwarf breeding program, most experiment stations employed crosses between local tall varieties and the exotic dwarfs like T(N)1 or IR. 8. In the F_2 generation of such crosses, the frequency of tall phenotypes is 3 times that of the dwarf plant types sought by the breeders. Further, the expression of vigour (a major criterion of selection) in dwarfs is determined by their location relative to talls. Since the talls are more competitive, even genetically superior dwarf plants surrounded by a greater number of tall plants are likely to appear unthrifty and thus get discarded. To overcome this problem, techniques have been developed and employed whereby dwarf seedlings are distinguished in the seed-bed from talls and the latter rejected prior to planting. As a consequence, nearly pure stands of dwarf F_2 populations have been planted and employed for selection, thus rendering the phenotypic selection more valid and dependable.

The programs in India employed over 200 indigenous varieties in crosses with the dwarfs and of these, dwarf selections with very high yield potential (Jaya, Vijaya, IET 1991 and IET 1039) originate mainly from 3 tall varieties—T 141, GEB 24 and T 90. This observation indicates how critical the choice of tall parents is in production breeding. A technique whereby the yield potential of the tall variety could be assessed unhindered by the poor plant type milieu in which the genotype exists, has been developed. As per this technique, tall varieties are grown under wide spacing, heavy fertilization and propped in open cages to permit an even exposure of foliage to solar radiation while preventing lodging. Elite tall varieties like H 4, W 1263, Handiquesali, BAM 9, etc. were thus identified and employed in the breeding programs.

Breeding for Grain Quality

Until 1970, the only fine grain dwarf variety available in India was Hamsa, a variety with relatively low yield potential. The situation was soon to be changed thus providing a wide range of choice in gradations of grain quality, duration and pest-disease resistance. Vijaya matures in 140 days and has medium slender grains with yield potential close to the coarse grain variety, Jaya. Ratna has attractive long slender grains, is earlier in maturity to Jaya by about 10 days and has moderate yield potential. Even more significant are materials developed more recently such as IET 1991 and IET 1039. The variety IET 1991 is similar in maturity and yield potential to Jaya while IET 1039 is similar in duration and yield potential to IR. 8. This pair of varieties is expected to convert even the hard-core conservative farmers in their patronage to dwarf varieties. Between these two again, IET 1991 has a slight edge over IET 1039, for reasons of better grain quality, earlier

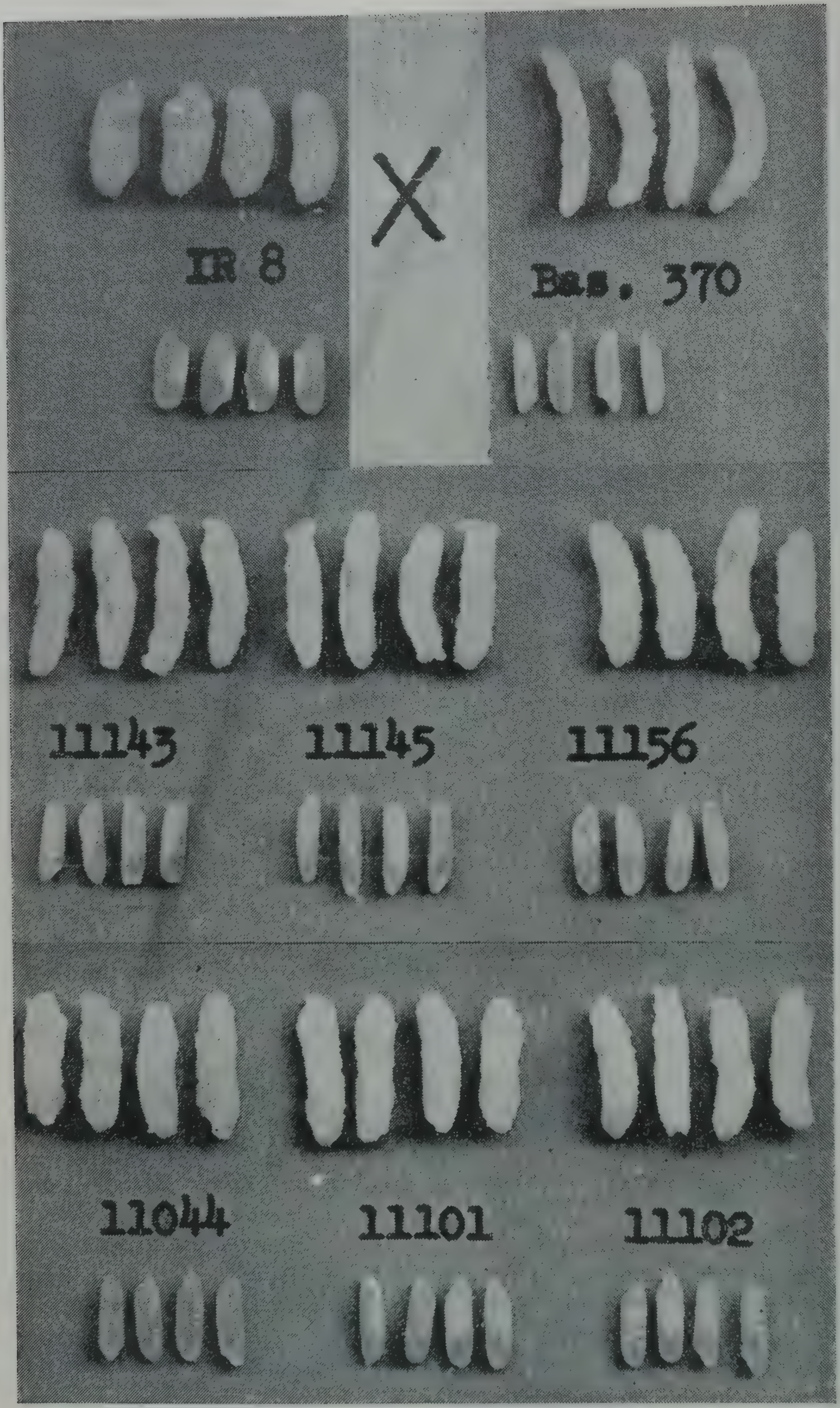


Fig.6. consumer-preferred quality of elongation on cooking has been transferred from low productive Basumati rice varieties to more productive dwarf varieties - AICRIP report, kharif 1970

maturity and higher yield potential.

Another significant advance in breeding for superior grain quality is the evolution of varieties with Basmati type of grain and yet exhibiting a high yield potential. Notable among such selections are—RP 107-1, RP 107-11 and New Sabarmati. These varieties exhibit distinct elongation on cooking Fig. 6).

Breeding For Adverse Water Situations

In the early days, it was envisaged that specific breeding projects are necessary to evolve varieties suited for drought, salinity, etc. Subsequent experience clearly brought out that the so-called drought resistant (MTU 17, Lalnakanda, etc.) and saline resistant (SR 26B, Getu, Damodar, etc.) varieties are inferior to the new dwarf varieties in yields even under respective stresses. In other words, drought and salinity, in the sub-lethal range, are progressively being recognized as non-specific stresses which reduce the yields of a group of varieties nearly uniformly. Consequently, a variety with high yield potential is even more relevant in the context of non-specific stresses.

Deep water conditions might, on the other hand, require special attention. Experience in Thailand and IRRI indicate the possibility of conferring an additional production advantage to deep water rices by incorporation of the gene promoting elongation of inter-calary meristem. Work in this direction needs to be intensified in India.

Problem of waterlogging has been studied in great deail. *A priori* the suggestion was for a separate plant type with intermediate stature, stiff straw, moderate to low tillering ability and late maturity. Basic problems of waterlogging are restrictions on nitrogen management during crop growth and retardation of tillering. Since the environment is restrictive on tillering, it should be obvious that a variety with higher tillering ability would be more suited to waterlogged conditions. Both from the points of view of tillering promotion and of management of nitrogen, the crop in waterlogged areas would have to be started ahead of upland areas such that tillering is completed by the time waterlogging would become serious. Once tillering is completed, even a

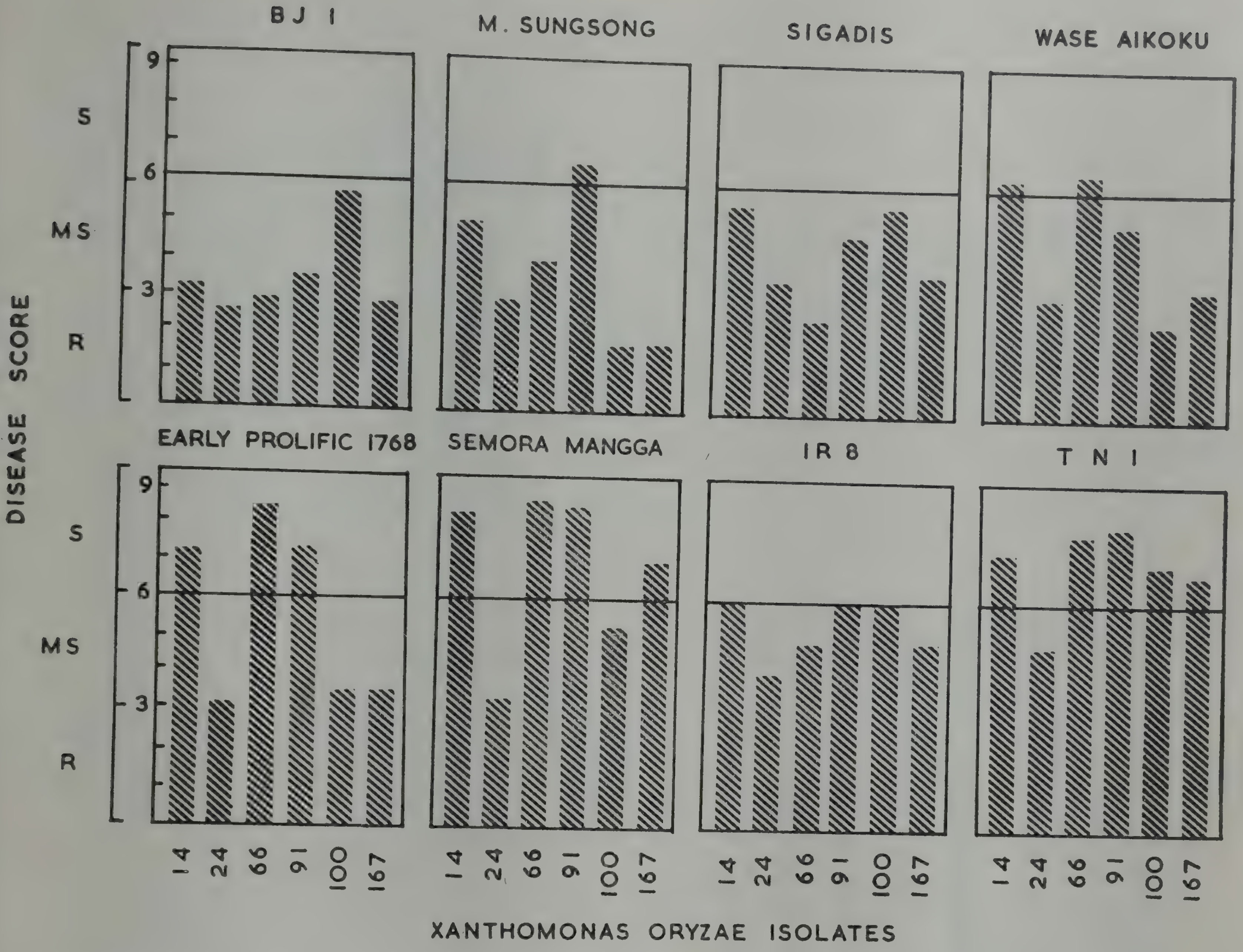


Fig.7. Strainal variation in the pathogenicity of xanthomonas oryzae (organism causing bacterial leaf blight) makes it imperative to rely one more than one donor in breeding for resistance.

sheet of water of 30—60 cm depth is not harmful to the dwarf rices. Current thinking on breeding for waterlogged areas is therefore directed towards developing late maturing varieties (photosensitive or otherwise) with high-tillering potential. Materials specifying the above conditions as examplified by RP 5—32, RP 193-1 are in extensive field tests in some parts of India.

Resistance to Pests and Diseases

It is often stated that high-yielding varieties are more susceptible to pests and diseases than the traditional tall varieties. This misconception results from the fact that the conditions (high plant population and heavy fertilizer application) under which the high-yielding varieties are grown provide more favourable microclimate for the epiphytotics and epidemics to occur. This is the major reason why pests and diseases hitherto considered minor in importance such as—rice tungro virus, leaf and planthoppers, leaf folders, bacterial leaf blight—are assuming serious proportions with popularization and extensive cultivation of dwarf rice varieties.

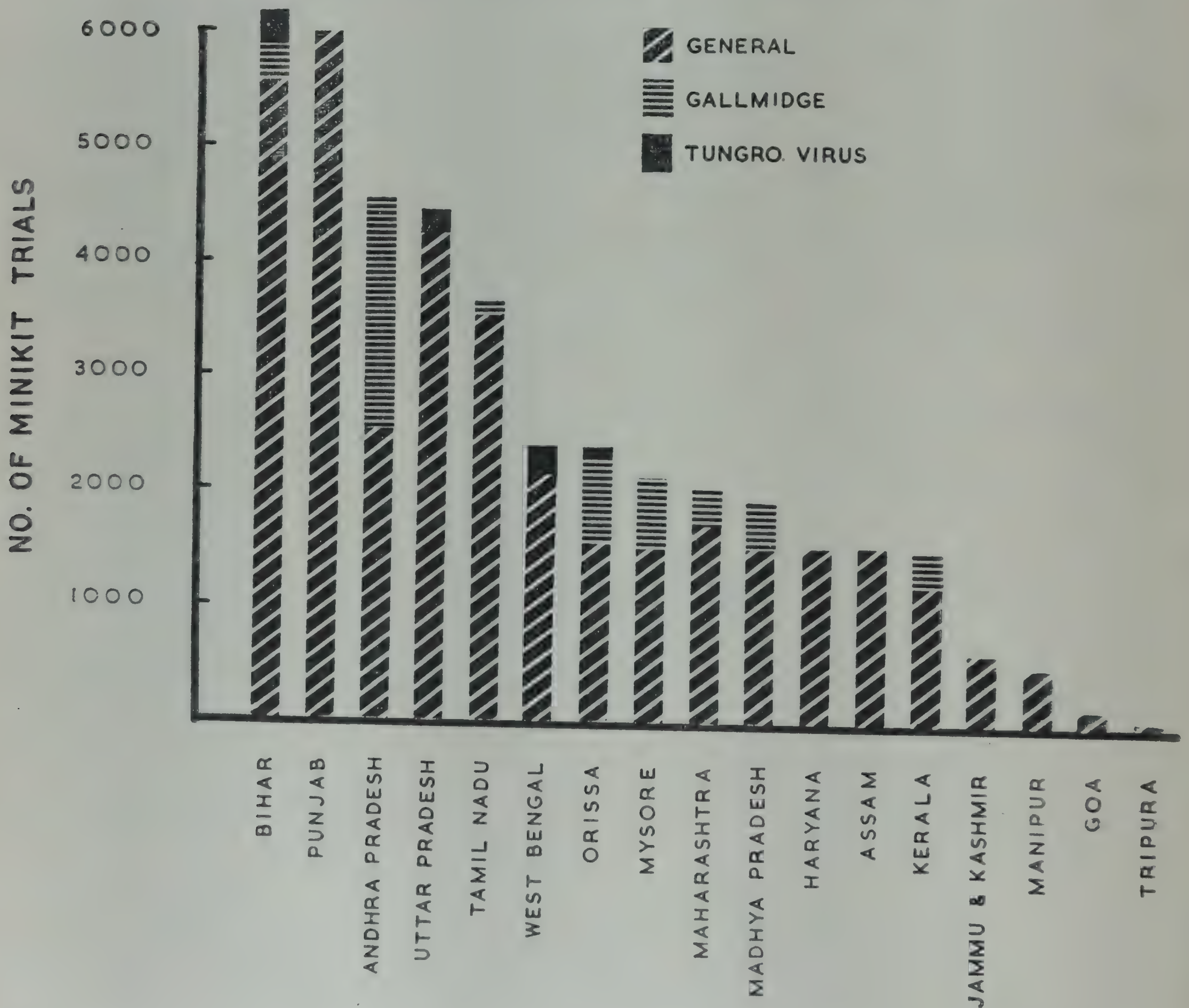
With a few exceptions, most of the dwarf photoinsensitive varieties are moderately resistant to rice blast. Vijaya is moderately resistant to rice tungro virus and green leafhoppers. Jaya is less susceptible to bacterial leaf blight and rice tungro virus compared to T(N)1. IR. 20 is moderately resistant to rice tungro virus, green leafhoppers and bacterial leaf blight.

It is unrealistic to expect incorporation of all pest-disease resistance factors in any one variety. Further, this may not be needed since all pests and diseases are not expected to simultaneously threaten rice production in any one locality. While there is no question about the need for intensification of research on breeding for pest-disease resistance, both from the points of view of farmers' economy as well as from the avoidance of pesticide residue hazards, rational consideration of this problem requires several approaches to be pursued.

(a) *Priorities.* Greater emphasis on resistance to bacterial leaf blight and rice tungro virus among diseases, and to gall midge and leaf and planthopper complex among the insects, is immediately obvious. These pests and diseases are very rapid in their multiplication and it is too difficult to control them chemically. In contrast, the pests and diseases which are hoststage-specific (cut worms, helminthosporium) or those in relation to which avoidance or compensating mechanisms are more easily found (stem borer, blast) might receive relatively lower priority. For example, with the exception of hilly regions where blast is a serious problem, environmental conditions prevailing during the main growing season (kharif) would avoid the climatic factors suited for quick build up of blast disease. Dwarf varieties, by virtue of their heavy tillering ability, offer an indirect mechanical advantage to the host under moderate levels of infestations by rice stem borer. On the other hand, heavy tillering ability of the dwarfs predisposes them to pests like gall midge, green leafhoppers and planthoppers.

(b) *Donors and Their Evaluation.* Plant exploration in northeast India

Fig.8. Spread of the Rice Minikit programme in different states, kharif 1972



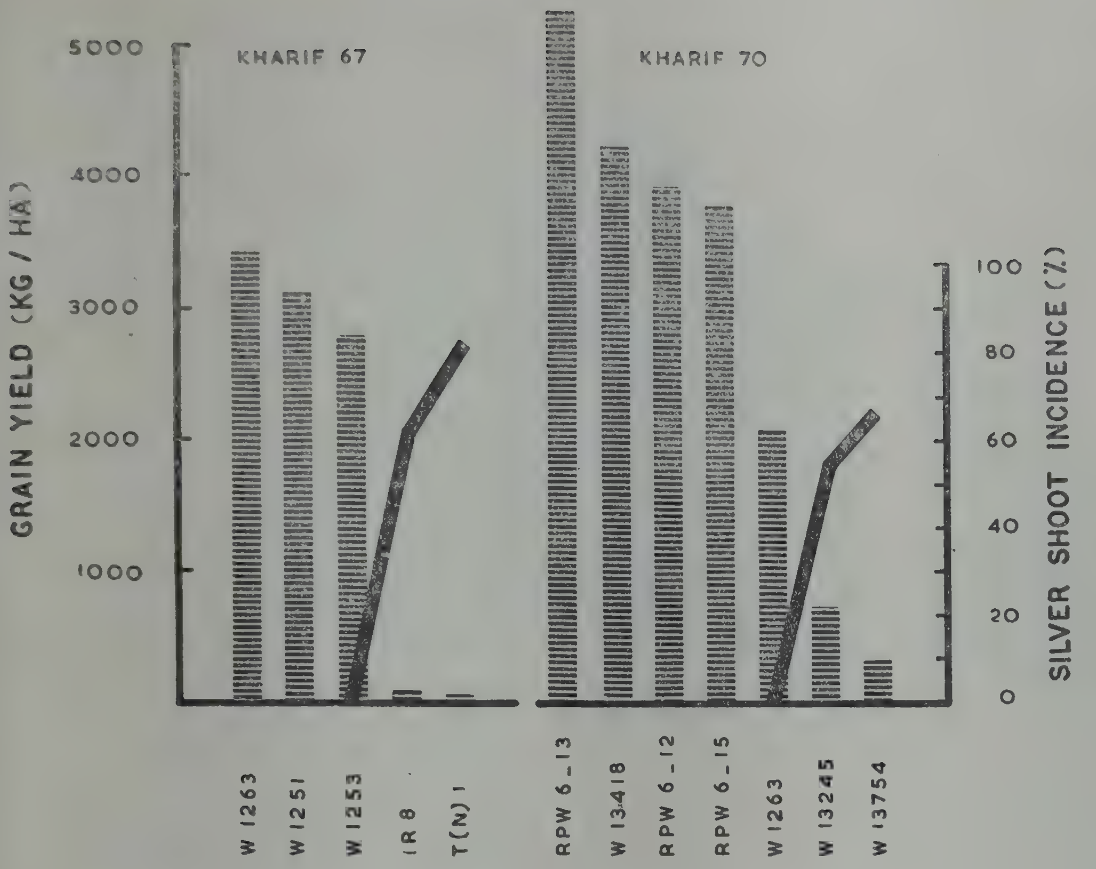


Fig. 9. Progress in breeding for resistance to gall midge. In 1967, there were no dwarf varieties to match the tall resistant varieties (w1263, etc) for the pest situation. In 1970, highly productive resistant dwarfs were available.

made it possible to collect nearly 10,000 primitive cultivars. Most of these have been subjected to screening tests aimed at identification of new donors for resistance to pests and diseases. Several varieties which exhibit resistance to gall midge, bacterial leaf blight, rice tungro virus and blast, have been identified. One might wonder why additional search for new donors is necessary for the pests and diseases enumerated above and in which, instances of host plant resistance have already been known. In breeding for resistance to pests and diseases, reliance on a single source might be hazardous for several reasons.

The donor in certain instances might prove to be a poor combiner when the program might end up with another donor, but not a variety of immediate commercial value. Citing a few instances, among the tungro resistant donors, Latisail proved to be a good combiner although it is itself a symptomless carrier for the disease. Kataribhog which is immune to rice tungro virus is not as good as Latisail in producing good plant type varieties while Ambe-

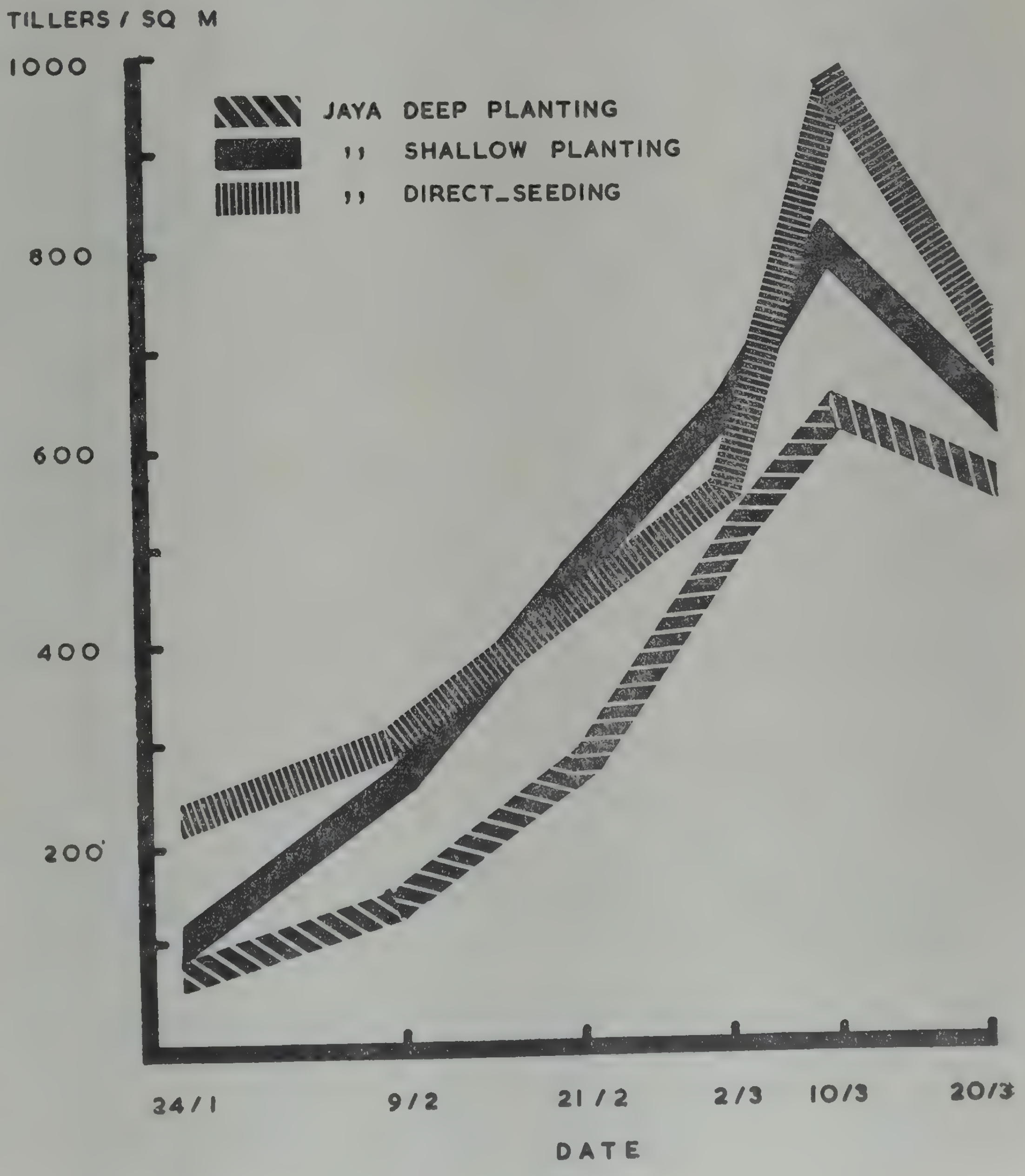


Fig.10. Tillering is delayed and depressed when seedlings are planted deep.

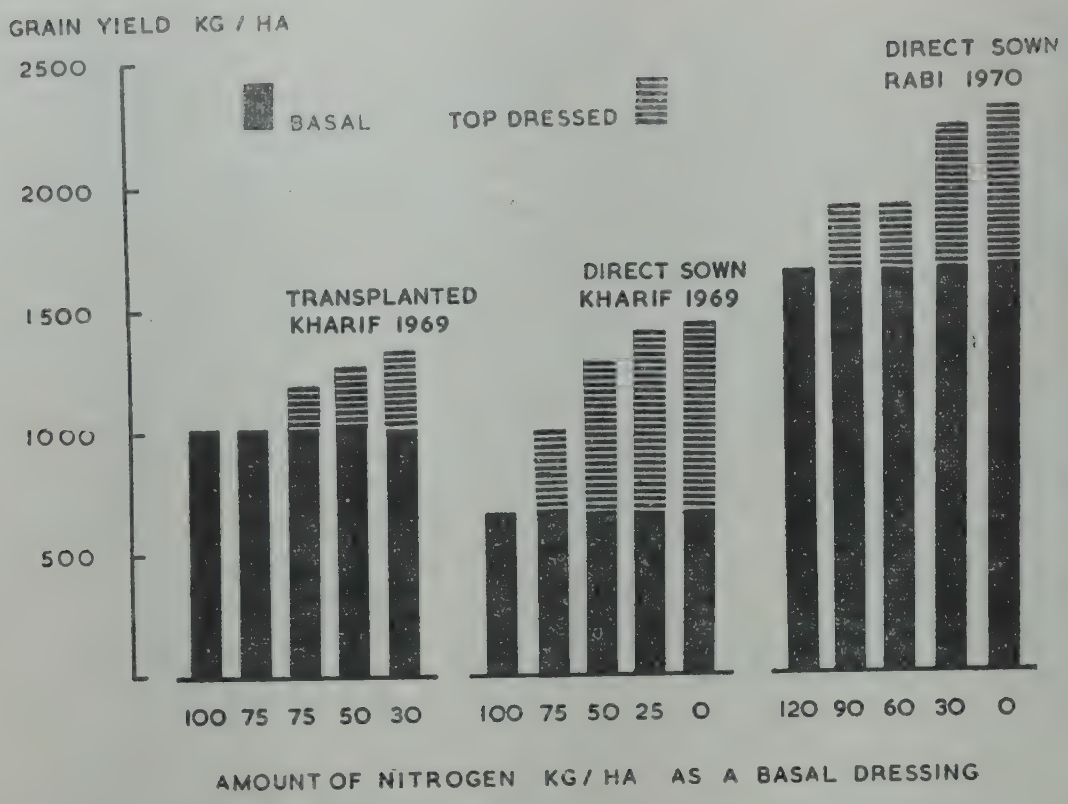


Fig.11. Split applicaton is 30-50 per cent more efficient than application of all Nitrogen as basal-AICRIP reports.

mohar and Pankhari 203 (other donors for rice tungro virus) are extremely poor in transmission of rice tungro virus resistance to dwarf plant types with good vigour. Likewise, in breeding for resistance to bacterial leaf blight, Sigadis with moderate resistance proved to be a better combiner than BJ 1, a better donor for resistance.

The donor may not cover the potential or even existing variation in the pest or pathogen. *Piricularia oryzae*, the causal agent for the blast disease has long been known to be differentiated into races. While many varieties exhibit moderate level of resistance to a good number of races, it is only a few like Te-tep, Tadukan, Carreon and Mamoriaca which maintain "global" resistance to races prevalent in different parts of the world. Similarly, variation in pathogenicity has been identified in bacterial leaf blight, wherein the isolates of the pathogen from different locations in India exhibited sharp differences in reaction to different hosts (Fig. 7). Isolates of rice tungro virus collected from different locations in India indicate the differentiation of the virus into four distinct groups designated as RTV 1 to RTV 4. It is only one (Kataribhog) of the six donors that maintains near immunity to all the four strains and restricts the multiplication of the virus on entry into the host.

Breeding programs aimed at resistance to gall midge, employed different donors such as W 1263, PTB 18, PTB 21 and Leaung 152. There is some evidence that resistance of W 1263 might partially break down in some test locations and this data are indicative of possible biotypic differentiation in the pest. Thus it is evident that identification of donors with wide spectrum of resistance and incorporation of resistance from diverse sources would become imperative to meet the challenges posed by the pest and pathogen variations.

(c) *Genetics of Resistance.* The genetics of resistance to pests and diseases failed to receive the needed emphasis because of inherent problems such as—strainal variation in the pathogen/pest, lack of artificial mass rearing techniques and variation in expression of symptoms. Much progress has been achieved in understanding the genetics of resistance to two diseases—rice tungro virus and bacterial leaf blight—and two pests—stem borer and gall midge.

It was established that the variety Latisail carries two genes for resistance to rice tungro virus and the presence of either of the genes ensures "recovery" at the adult plant stage from initial susceptible reaction. This is an extremely interesting genetic phenomenon.

Critical studies in relation to the genetics of resistance to bacterial leaf blight involving 3 isolates indicated that resistance to different isolates is governed by different doses of complementation of genes from a common set and involving among them a common pair of epistatic-hypostatic loci. This system renders one of the isolates as key strain, the resistance against which automatically confers resistance to the other two isolates, thus simplifying the screening procedures.

Genetic studies on resistance to stem borer indicated simple genetic control for resistance in the variety TKM 6. This study which employed natural infestation developed several techniques in quantifying the level of resistance in the genotypes of the segregating material while relying upon natural infestation.

Studies on genetics of resistance to gall midge indicate the operation of inhibitors and basic genes for resistance. It was also evident that the genetic basis for resistance in W 1263 relies upon a single gene for resistance while that in PTB 21 relies upon 3 basic genes for resistance. Future trends in research would involve the tests of allelism for the resistant genes in the donors and complementation of these for incorporation of more stable resistance into the dwarf plant types.

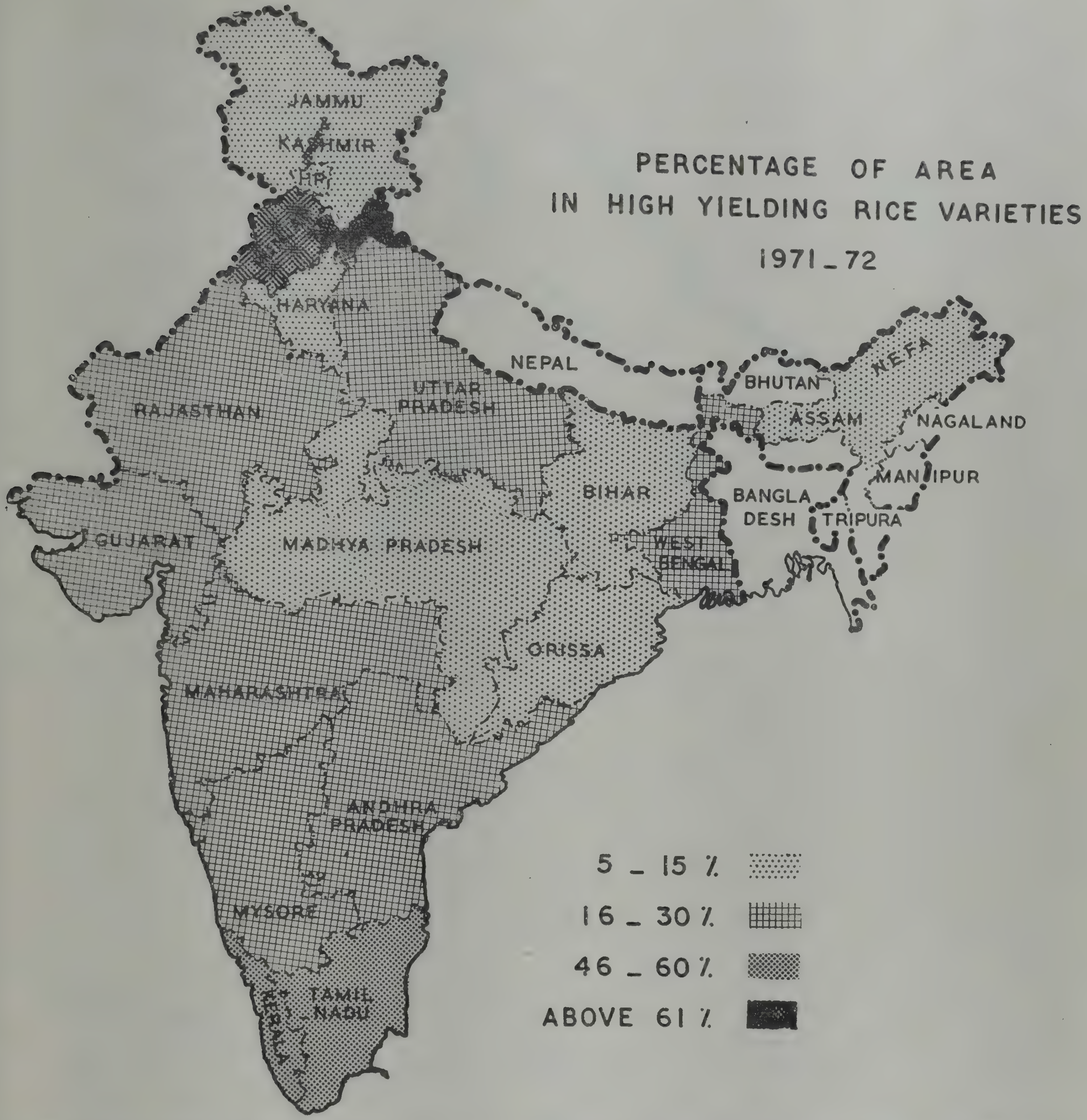

PERCENTAGE OF AREA
IN HIGH YIELDING RICE VARIETIES
1971_72
JAMMU & KASHMIR
HP
HARYANA
RAJASTHAN
UTTAR PRADESH
NEPAL
BHUTAN
NEFA
ASSAM
NAGALAND
MANIPUR
BIHAR
BANGLA DESH
TRIPURA
WEST BENGAL
GUJARAT
MADHYA PRADESH
ORISSA
MAHARASHTRA
ANDHRA PRADESH
MYSORE
TAMIL NADU
KERALA
5 _ 15 %
16 _ 30 %
46 _ 60 %
ABOVE 61 %

Fig.12. Coverage with high yielding varieties varied widely among different states of India—source: Department of Agriculture, Government of India.

Advances in Breeding for Resistance

Progress in breeding for rice tungro virus resistance was indeed rapid and striking. The disease was not known in India until 1967. Within a couple of years of identification of the disease, several new donors—Latisail, Ambemohar and Kataribhog—were identified and employed in hybridization. By the time the rice tungro virus epidemic of 1969 occurred in Bihar and Uttar Pradesh, Indian scientists were ready to screen hybrid materials against the more virulent race that involved in the epidemic. Pursuing an intensive screening in the green house for resistance and in the field for agronomic characters, the program identified by rabi 1972, seven selections which combine resistance with good yield potential. These materials are now in the field trials in the rice tungro virus endemic areas (Fig. 8).

Breeding for resistance to gall midge was next in accomplishment

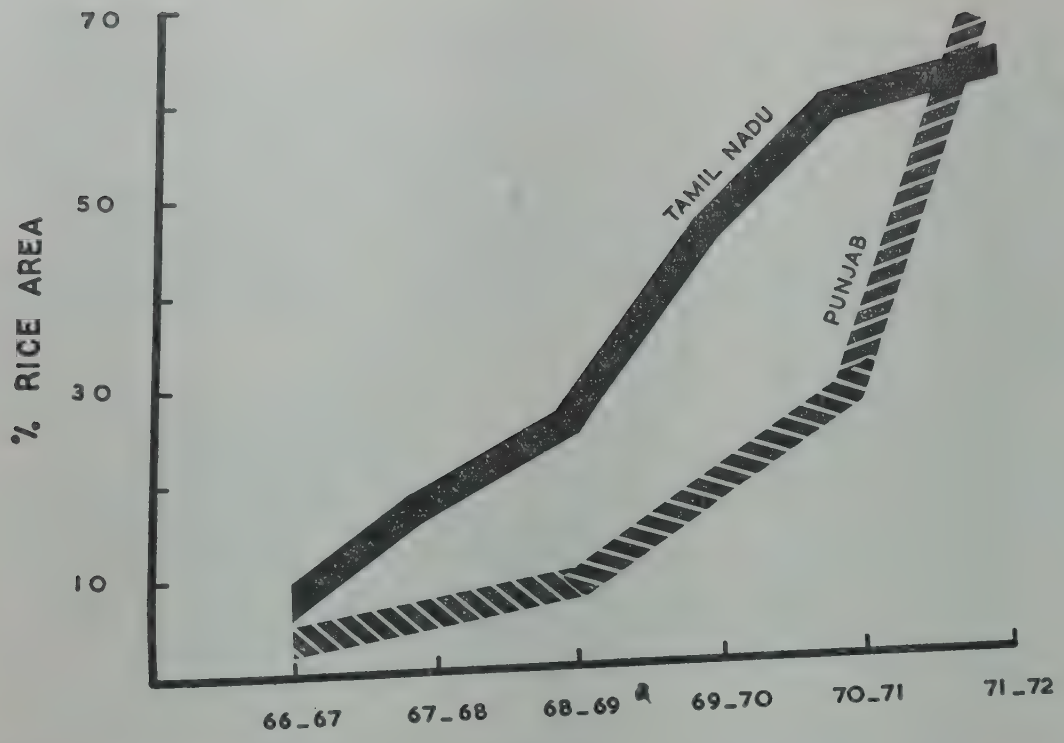


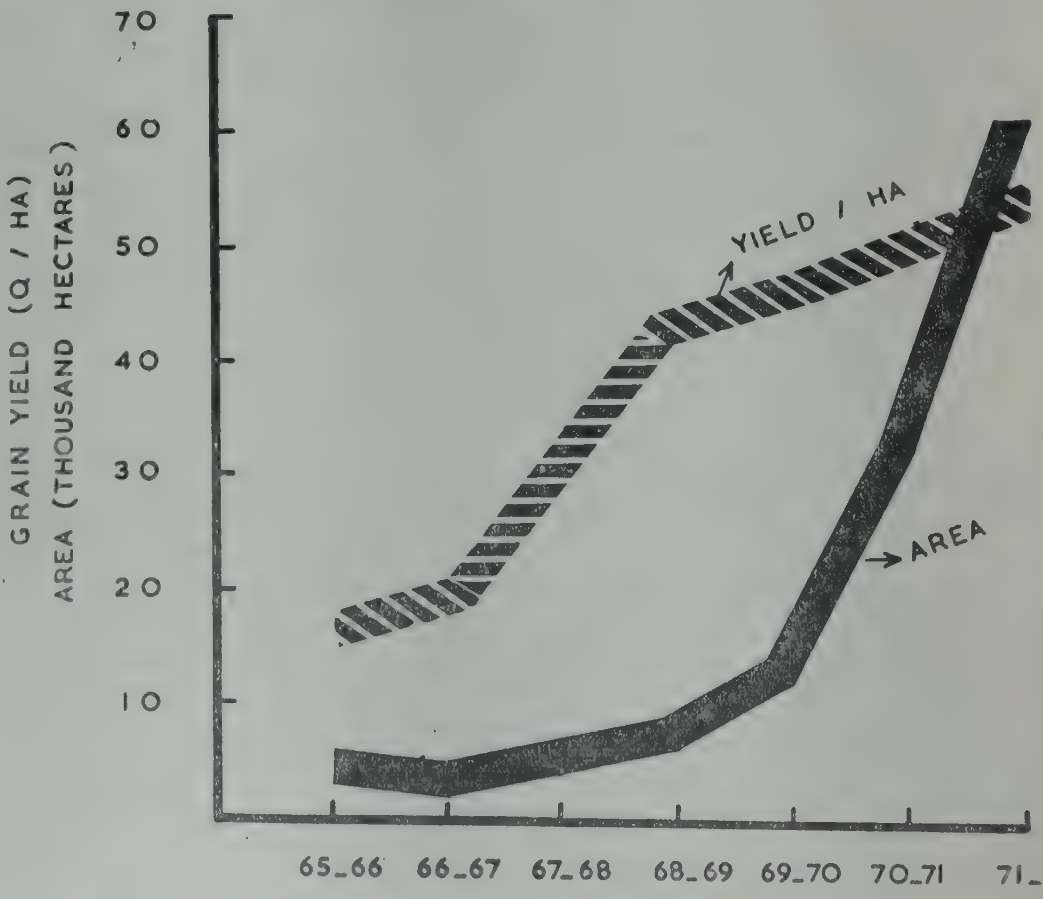
Fig.13. Tamil Nadu and Punjab lead other states in popularisation of high-yielding varieties source : B.P.Pal, IRRI, 1972

and importance. Resistant donors —PTB 18, PTB 21, Eswarakora and Siam 29—were identified by 1960. These donors have been employed in crosses with agronomic bases such as GEB 24 and MTU 15 since the donors possess several undesirable characters. As a result of these programs, better donors like W 1263 and CR 57-49 were developed by 1967. These derived donors were in turn crossed with the dwarf varieties and a set of 30 gall midge resistant dwarf varieties have been developed by rabi 1972. Some of these selections, viz., RPW 6-12, RPW 6-13, RPW 6-15, were proven to be resistant to rice gall midge not only in India but also in Indonesia, Thailand and Ceylon.

Varieties resistant to rice gall midge do not permit the continuation of the life cycle of the insect beyond first instar stage of the larva and in this respect, resistance in these varieties borders immunity and is qualitative, unlike in relation to stem borer where the resistance is more quantitative. In locations and seasons of heavy gall midge pressure and under conditions where the susceptible varieties completely fail to produce any grains, resistant varieties yield 4-6 tons/ha (Fig. 9) even under unprotected conditions. Even more interesting is the observation that many gall midge resistant varieties exhibit multiple resistance to other pests—thrips, leafhoppers, planthoppers, and leaf folders, Enormous possibilities for host plant resistance breeding have thus been opened up with the identification of gall midge resistant varieties.

Success in breeding for resistance to other pests and diseases has not been so striking. Ratna has only a moderate level of tolerance to stem borer and Vijaya to green leafhoppers. Among the experimental lines in advanced stages of testing, RP 31-49-2 is fairly resistant to bacterial leaf blight and blast and RP 6-516-33-1-1 is resistant to stem borer. The tasks ahead involve development of kharif season adapted varieties with multiple resistance to bacterial blight, rice tungro virus and leafhopper; and rabi season adapted varieties with multiple resistance to stem borer, blast and plant hoppers.

Fig.14. Area and productivity of boro rice increased as a result of popularisation of dwarf rice varieties Burdwan district, West Bengal.



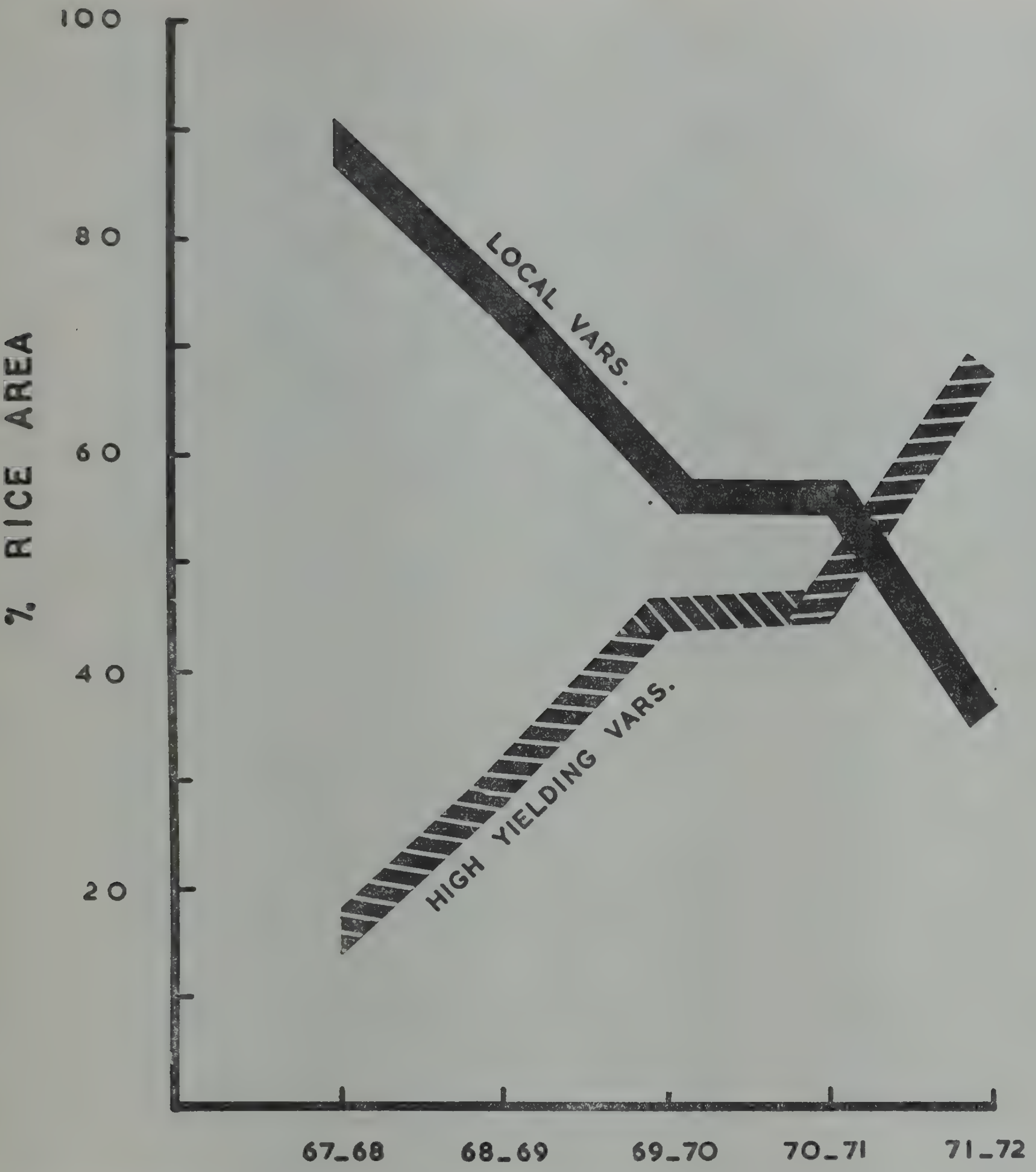


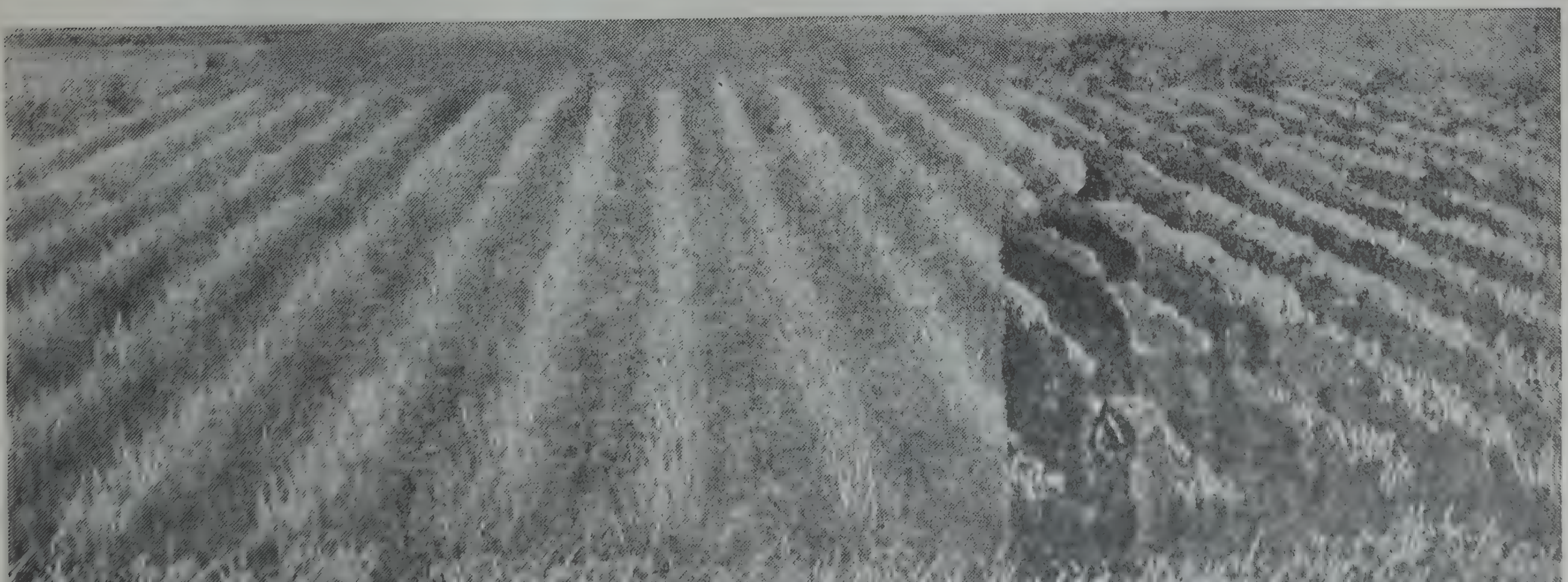
Fig.15. As dwarf rice varieties (mostly Jaya, IR 8) claim more and more of the area, traditional varieties lose the patronage of the farmers—rabi season, West Godavari, Andhra Pradesh.

Pest-Disease Surveillance

In self-fertilized crop plants like rice, host-pathogen reactions tend to be highly specific. Consequently, even a resistant variety might not be expected to stay so for a long time. A genetic change in the pathogen or a selection advantage for one of the constituents in the pest-pathogen complex might render the new variety susceptible with time. It is therefore essential that the resistant varieties are monitored from time to time for the stability of resistance and simultaneously alternate host genotypes introduced into the system. In the disease organisms with recognized strainal variation such as blast, bacterial leaf blight and rice tungro virus or in relation to the insects suspected of having biotypic variation such as gall midge, the need for pest-disease surveillance is even more evident.

Surveillance is a sure means of identifying the problem before it is serious and thus provide time for researh leading to a solution to the problem. Many instances are known where a pest or disease considered minor in economic importance some years ago is now a major pest or disease of consequence. Sheath blight, false smut, helminthosporium, rice tungro virus, leaf and plant hoppers and leaf folders are becoming increasingly menacing in many parts of India. Pest and

Fig.17. Bacterial leaf blight resistant lines stay green and healthy even under the conditions of severe disease pressure when the rows of susceptible Taichung (Native) are severely dried due to the disease—AICRIP, Kharif 1971.



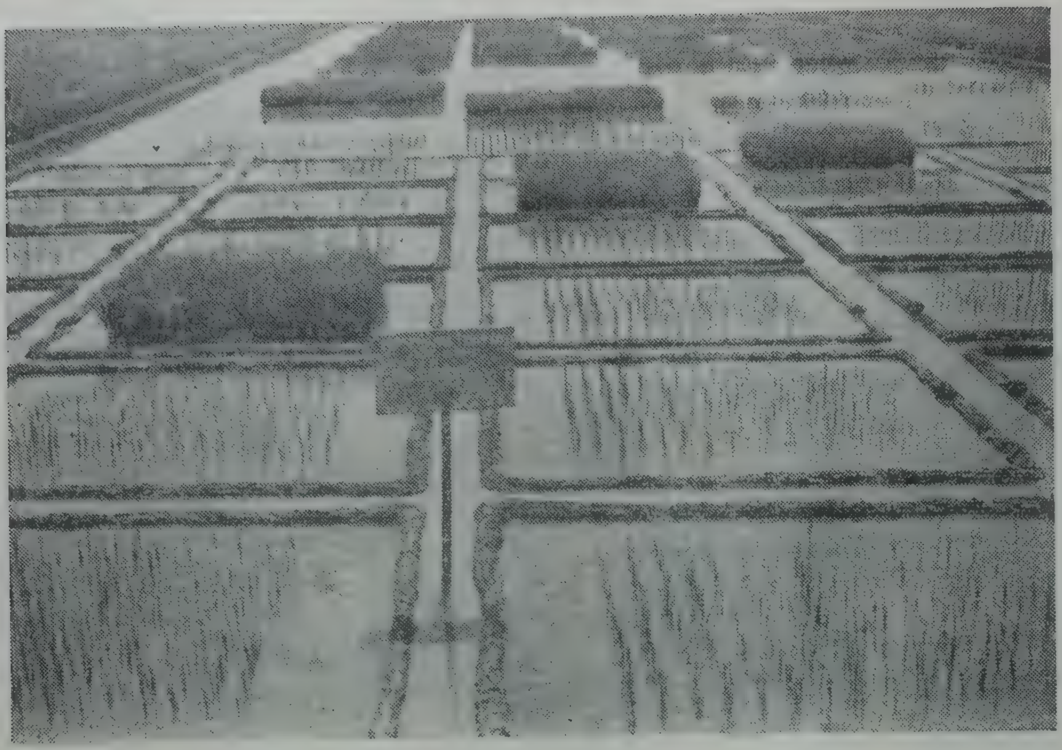


Fig.18. Phosphate deficiency restricts tillering in rice. A situation of P-deficiency at AICRIP, Rajendranagar, Hyderabad, kharif, 1971

disease surveillance is a part of logistics in deciding the quantum of research input necessary to counter an anticipated problem.

Management of Dwarf Varieties

Yield potential of the rice plant has been doubled with the breeding of dwarf varieties. In the context of this genetic advance, improvement of crop management practices are even more relevant since the new varieties are management responsive; and every improvement in management brings about an assured increase in crop production. Presently most of the farmers derive 50-60 per cent yield potential of a variety. In the management of the dwarfs cardinal principles are—maximization of tillering during the vegetative phase and maintenance of leaf function during the ripening period. All practices which tend to lower tillering such as poor incorporation of basal fertilizer, deep transplantation (Fig. 10), planting old seedlings, inefficient top dressing of nitrogen fertilizer, deep water and deficiencies of phosphorous and zinc—all result in low productivity.

The deficiency of zinc in high pH soils implicated in so called "Khaira" disease of Uttar Pradesh terai, is now recognized to be widespread in many parts of the country and is probably next in importance to nitrogen and phosphate.

Earlier recommendation that photoinsensitive, heavy tillering, early maturing, high-yielding varieties need to receive good part (50-75 per cent) of programmed nitrogen fertilizer as basal, is proved to be unsound. Irrespective of soil type, the benefits of split application of nitrogen become increasingly evident since under all conditions, water management in early crop growth appears to lead to extensive losses of added nitrogen. It is therefore safe to delay the nitrogen application so as to synchronize with active uptake by the plants. The magnitude of increase in efficiency of added nitrogen with split applications is approximately 30 per cent under transplanted and 50 per cent under direct-seeded conditions (Fig. 11). Reliable guide to practice of top-dressing is the condition of the crop as reflected in tillering.

Critical factors that promote rice production under low land transplanted conditions are therefore—(1) shallow (2-5 cm) planting of young (20-25 days) seedlings, (2) low water depth (3-6 cm) for the first 50 days after planting, and (3) draining the field prior to top dressing of nitrogen and reflooding 24-48 hours later.

Spread of new technology among vast number of rice farmers in India is a challenging task. Success varied with dynamism of local leadership, acquaintance of extension workers with the new technology, economic considerations of the farmers, climatic environment favouring production, prevalence of pests and diseases, magnitude of deviation from existing cropping systems and practices, etc. (Fig. 12). These variables are to be satisfactorily met if the potentials of the new technology are to be transferred into actual increase of production.

Spread of coarse grained high-yielding varieties (IR. 8 and Jaya) has been phenomenal in the kharif season of Punjab and Haryana (Fig. 13) the states hitherto considered stronghold of consumer preferred varieties with good grain type. Factors that promoted this change are—favourable climatic environment, organized extension system and the fact that rice is a cash-grain crop. Another success story is from Burdwan district, West Bengal during *Boro* season where the area cultivated has increased from 3,000 ha in 1966 to 60,000 ha in 1972 and in the same period, mean yields have risen from 1800 kg ha to 5630 kg/ha (Fig. 14). Again, IR. 8 and Jaya were the varieties which contributed to this change.

High-yielding varieties program has been both extensive and intensive in Tamil Nadu. The Department of Agriculture nearly saturated in a record time, the *Kuruvai* season of Thanjavur delta with the variety ADT 27, and gained major transformation of the single-cropped *Samba* area to a double-cropped

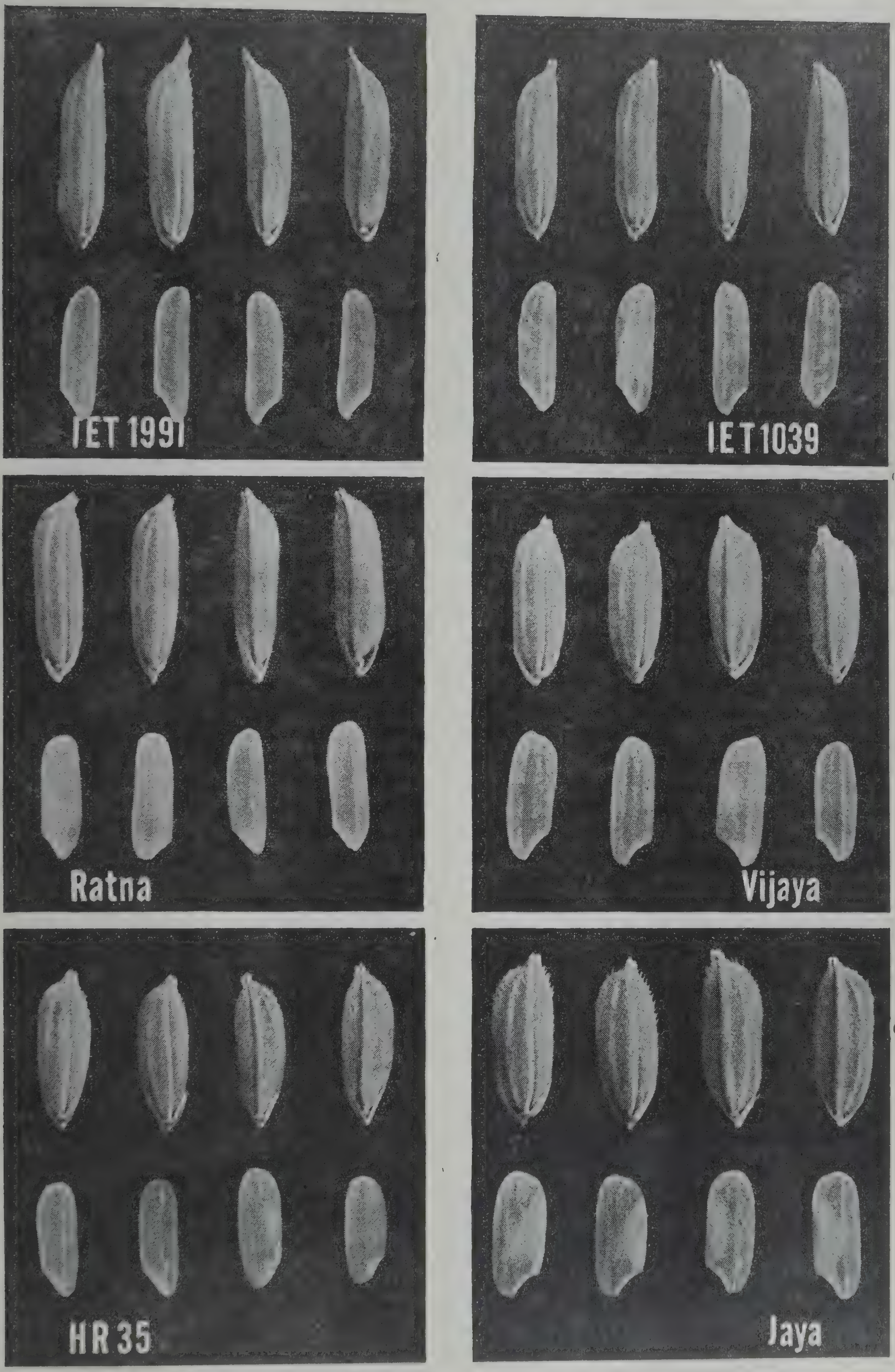

IET 1991
IET 1039
Ratna
Vijaya
HR 35
Jaya

Fig. 19. Major improvement on grain quality retaining the high yield potential

Kuruvai-Thalladi pattern. More recently, the northern districts of the state have been the site of change where the low productive TKM 6 and Co 29 have been replaced by IR. 8, IR. 20 in 50-60 per cent of the area in 2-3 years.

In contrast, a slow but steady acceptance of the dwarf varieties is typical in West Godavari district of Andhra Pradesh during rabi season (Fig. 15).

Primary conclusion to be drawn from the three case studies is that the new technology with potential for increased production has an opportunity to produce visible changes in situations where it is pursued on a campaign basis, as was done in Punjab, West Bengal and Tamil Nadu. With the object of taking the new varieties to a large number of farmers simultaneously and thus minimize the timelag between availability and exploitation of new varieties, a new program of Minikit trials has been launched in rabi 1972 cooperatively by AICRIP, Rice Development Directorate of the Government of India and the state departments of agriculture.

The implementation of Minikit program synchronized with the availability of fine grain high-yielding varieties—IET 1991 and IET 1039. Each farmer, as per the program, received 2 kg seed of the new varieties for growing in an area of 1/25th of a hectare surrounded by a variety of his choice. In a chosen district, a large number of farmers (200-500) participate in the program such that the message of the new varieties is widely scattered. If the new variety performed well and is acceptable to the farmer, each of the farmer would thus have in his possession, 200-400 kg of seed which he could either use in his own holdings, or share with neighbours in the following season. During rabi 1972, the program operated in 4 states—West Bengal, Andhra Pradesh, Mysore and Tamil Nadu. The feed back and impact were so enormous that the program has now been extended from 3,000 trials in rabi 1972 to 44,000 trials in kharif 1972. The program has been expanded so as to include pest-disease resistant varieties as well as the fine grain high productive varieties (Fig. 8). The impact of the Minikit program would be evident from the fact that IET 1991 which was in approximately 1500 Minikit trials all over Andhra Pradesh covering an area of 60 ha is now estimated to cover 15,000 ha during kharif 1972. Hopefully, the new introductions in the Minikit program would bring about similar changes in other states as well.

Outlook for Future

Rice research effort moved away from a contracted vision of solving a local problem with local resources to a national and international plane. Coordinated multi-disciplinary approach to crop improvement has come to stay as a system designed for speedy solution of immediate and long range problems. Communication gap among the rice scientists within the country and of Indian scientists with other countries has been greatly narrowed down. Techniques and materials developed in India are beginning to influence research elsewhere. The evolution of gall midge resistant varieties and identification of pest-disease resistant varieties are in this direction.

A new confidence among the scientists in tackling the problems of the country and of the extension workers in bringing about a major transformation of agricultural systems is evident. With these basic changes, a major breakthrough in rice production of the country is very much in sight.

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PROGRESS AND PROSPECTS OF MAIZE RESEARCH IN INDIA

JOGINDER SINGH
Project Co-ordinator (Maize), I.C.A.R.,
(Genetics Division, I.A.R.I.), New Delhi

SINCE independence, the Indian farmer has grown twenty-five kharif crops of maize—a cereal with highest yield potential. During the last 25 years, the position of maize in India has been markedly altered from an imported to an exported commodity. For the first time, substantial quantities of maize, of an order of two lakh tonnes, are being exported to Japan and Mauritious. Since Indian starch industry has also made a marked progress, it is likely that in future years several maize products will also be exported.

During the last 25 years, area, production and yield per hectare of maize in India has registered an annual increase of 3.5, 8.1 and 3.1 per cent, respectively (Figure 1). During 1970-71, maize was planted on 5.8 million hectares and it registered a record production of 7.4 million tonnes, to which the States of Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, Punjab, Jammu and Kashmir, Himachal Pradesh and Gujarat made over 90 per cent of the contribution. With the present trend in growth rate, the target of 8 million tonnes for the current Plan is well within reach. While over 80 per cent of maize produced in India is consumed directly as food, considerable scope for industrial utilization and animal feed still exists. Poultry alone is likely to consume 1.5 million tonnes of maize if the per capita consumption of eggs, as visualized in the current Plan, is to be raised from 8 to 40. Likewise, maize requirement for swine and cattle feed is likely to be witnessed at a still higher level in the near future.

Research Organisation

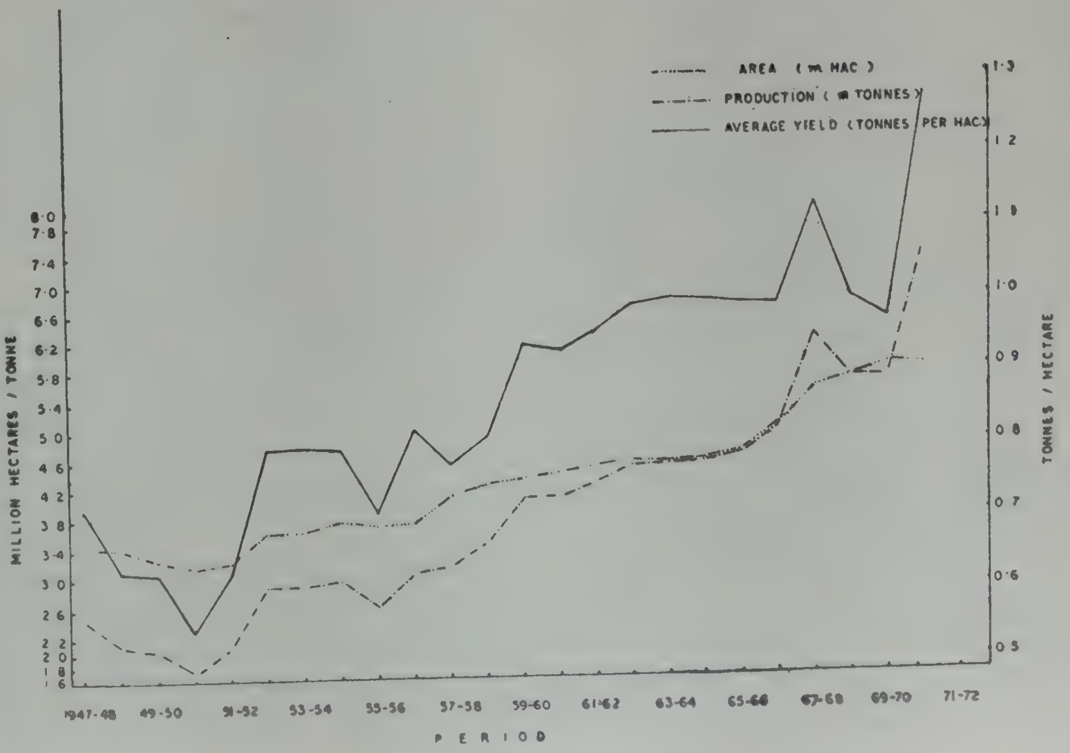
Prior to 1957, maize research in the country was carried out in various States in the form of number of independent research projects financed by the Indian Council of Agricultural Research. Taking stock of the progress, the problems and available facilities at the various research centres in 1957 the entire maize research programme was reorganised into a coordinated project — a pattern which has now been accepted and adapted by the Indian Council of Agricultural Research as a model of research for other crops as well.

In order to tackle the specific regional problems under the Coordinated Maize Improvement Scheme, various maize growing regions of the country were grouped into four agro-climatic zones, cutting across the State boundaries. Even though, maize project was started with the main emphasis on breeding, it was soon realized that supporting disciplines like agronomy, entomology, pathology and biochemistry were vital for the overall improvement of the crop. Additional disciplines were, therefore, added during 1963. The keynote determining the success of coordinated maize project rests in the inter- and intra-disiplinary, multi-location problem oriented evaluation tests and ungrudging cooperation of research workers at all research centres.

High-yielding Maize Varieties

In 1961, four high-yielding maize hybrids, namely, Ganga 1, Ganga

Increase in area, production and yield per hectare of maize



Kuruvai-Thalladi pattern. More recently, the northern districts of the state have been the site of change where the low productive TKM 6 and Co 29 have been replaced by IR. 8, IR. 20 in 50-60 per cent of the area in 2-3 years.

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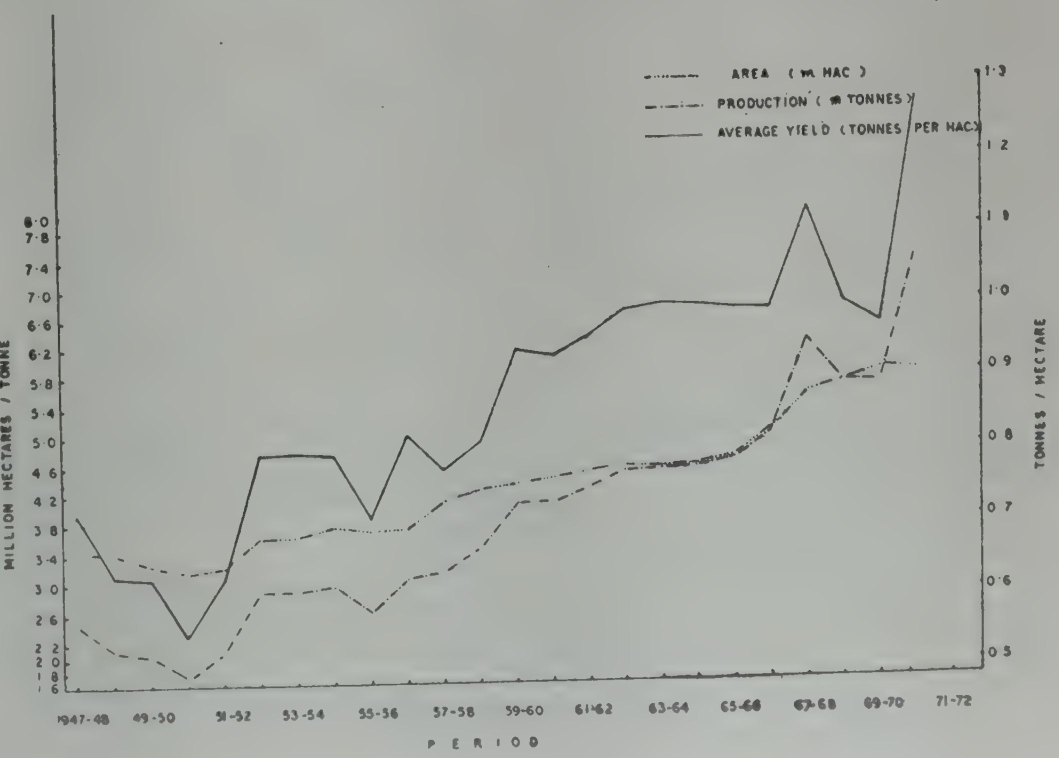
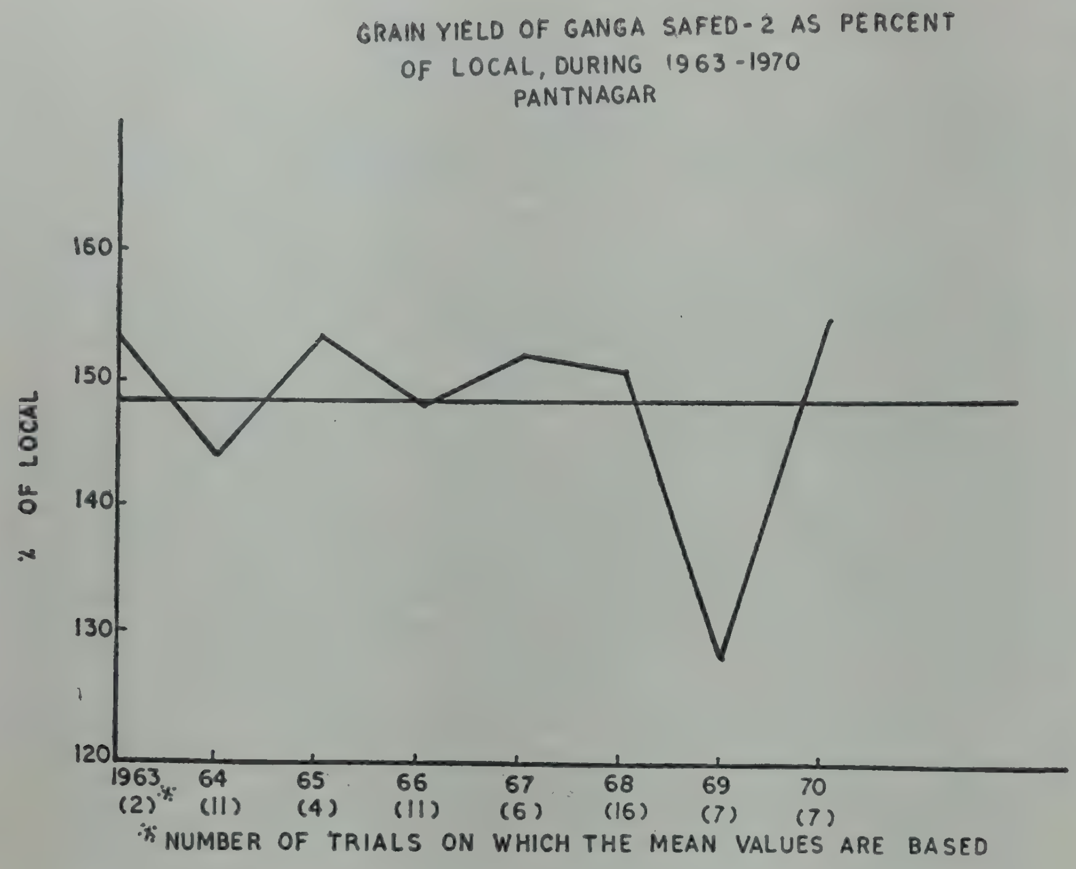


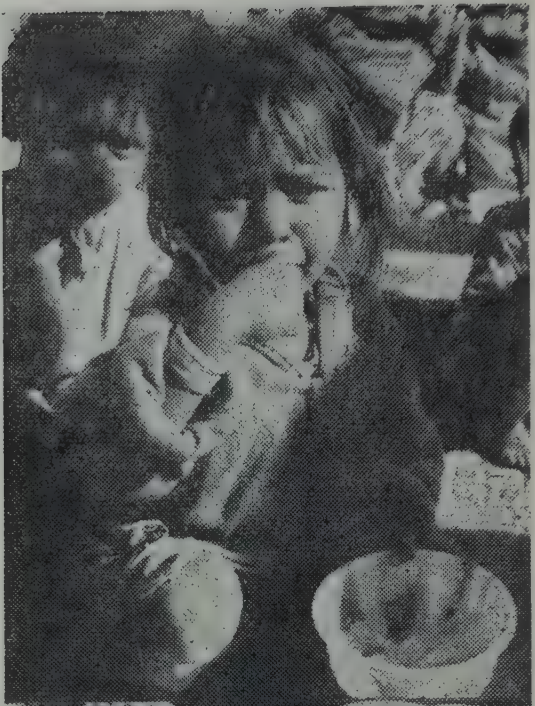


Grain yield of Ganga Safed-2 as per cent of local during 1963-1970, Pantnagar

101, Ranjit and Deccan, developed by the Coordinated Maize Improvement Scheme, were released for commercial cultivation. Following this initial release, 5 more maize hybrids have subsequently been developed and released for different maize growing regions of the country. Table 2 records the details of various maize hybrids released by the Coordinated Maize Improvement Scheme. Himalayan 123, a yellow double cross hybrid recommended for the high elevations has given a yield of up to 8-10 tones/ha; Ganga Safed 2, a white double top-cross is already very popular in the states of Bihar and Uttar Pradesh; Hi-Starch, a white-dent hybrid, is especially suited for starch industry, while Ganga 5, released in 1968, in addition to high degree of resistance to brown stripe downy mildew (*Sclerophthora rayssiae* var. *zeae*) has given very high yield and has shown wide adaptability. Maize hybrids, in general, have given 30-50% or more yield than the local varieties under recommended cultural practices, at the various research stations (Figure 2) as well as in large scale demonstration trials (Figure 3). Maize hybrids developed in India have also done well in a number of other Asian countries; their performance in the Indian Peninsula, in particular, has been outstanding.

Development and release of maize composites in 1967 has been another significant milestone in the history of maize research in India. Unlike, in the successful cultivation of hybrid maize wherein the regular availability of fresh F_1 hybrid seed is a pre-requisite, farmers themselves can save or multiply seeds of the appropriate composites. Composites like Vijay, Kisan and Amber have shown wide adaptability in addition to high yield potential. These composites also have a marked resistance to important diseases and pests.

More recently signficant improvement in protein quality has also been brought about through the use of opaque-2 and and floury-2 genes. Traditional maize varieties even



A young girl relishes the porridge made from opaque-2 maize

Ganga 3 an early maturing, high-yielding hybrid

with 12-14% total protein are very poor in the essential amino acids like lysine, tryptophan and methionine. The released opaque-2 composites—Rattan, Shakti and Protina contain 100% and 60% more lysine and tryptophan respectively than the normal maize varieties and also have marked decrease in leucine content. These composites are, therefore, more suitable for direct human food as well as a feed for non-ruminants.

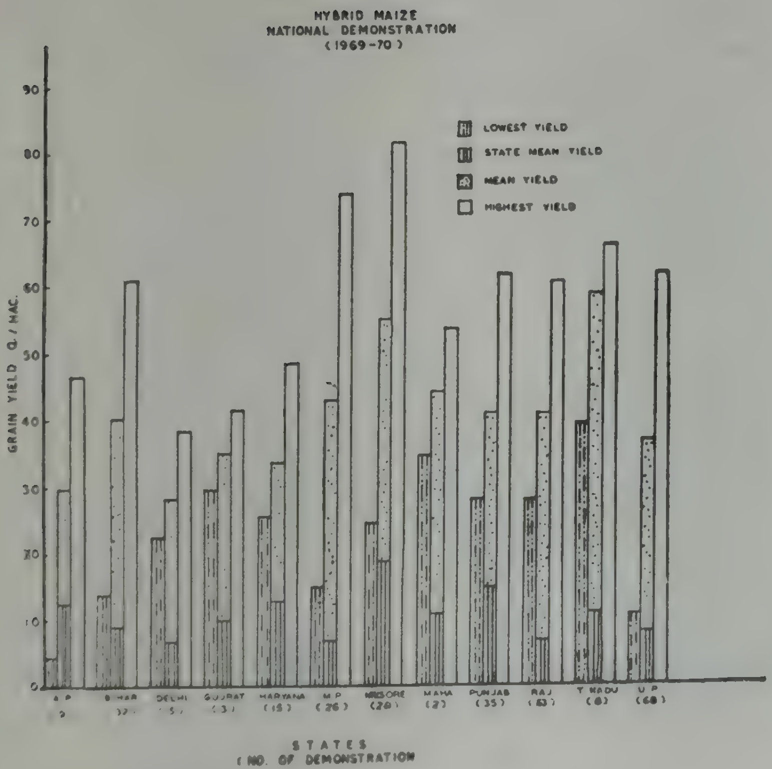
The importance of using opaque-2 maize in the diet of young children has also been demonstrated in a recent study carried out in Nangloi (Delhi State), wherein two groups of children of 6-36 months of age, selected from the low income group were fed on opaque-2 maize and skim milk. Weight gained by children fed on opaque-2 maize for 60 days was more than the other group fed on skim milk (Table 1). Nutritional superiority of opaque-2 maize in the diet of growing children has also been demonstrated in feeding experiments carried out in Guatemala, Colombia and the U.S.A. Superiority of opaque-2 over normal maize as an animal feed has adequately been proven for swine and poultry.

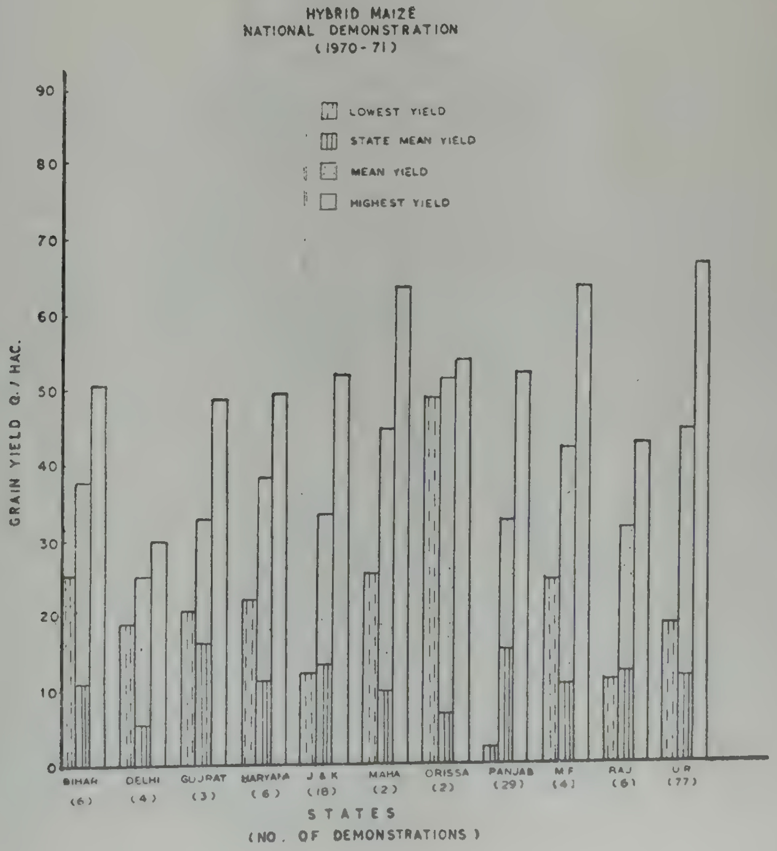
In more recent years, maize research workers have been engaged in the improvement of elite composite populations for yield, disease and pest resistance and other desirable agronomic characters by using various selection schemes like mass selection, full-sib family selection, reciprocal recurrent selection, etc. The reselected populations have not only given higher yield *per se* but have provided the elite base materials for the development of better combining lines. Some of the experimental hybrids involving the lines selected from the improved composites following one cycle of reciprocal recurrent selection have given 11-17% more yield than the experimental hybrids under cultivation.

Diversification in the Utilization Pattern of Maize

A substantial part of maize produced in India is consumed in the form of boiled or roasted green ears and as pop corn. For the various uses, till recently only flint varieties were grown. High-yielding pop and sweet corn varieties are now available for growing in the Indo-Gangetic Plains and Peninsular India. With the availability of these varieties pop corn and sweet corn has already become popular in urban areas.

In India, maize is being processed by the wet and dry milling industry and an array of products are being produced. These products range from breakfast foods like corn flakes, basic raw materials like starches, dextrose to highly sophisticated pharmaceutical products and industrial chemicals. Purified oil, a by-product of starch industry extracted from maize germ is highly polyunsaturated and is an excellent cooking media. With our present knowledge of maize genetics it is possible to develop maize varieties which are specially suited for specific industrial uses. Research work with a view to further diversifying the utilization pattern of maize has already been initiated.





Desirable Plant Type

The morphology and physiology of the maize plant has to be suitably modified so as to provide better economic yield under specific environments. Even with the existing level of photosynthesis it is possible to increase yield through increased sink size, which in turn can be attained by prolificacy or through increase in ear size. Prolific types have a better stability under stress environments. Some of the prolific selections made from 'prolific composite' have given 15-25% more yield than the released composites under cultivation. Further work with regard to the development of better prolific populations is underway.

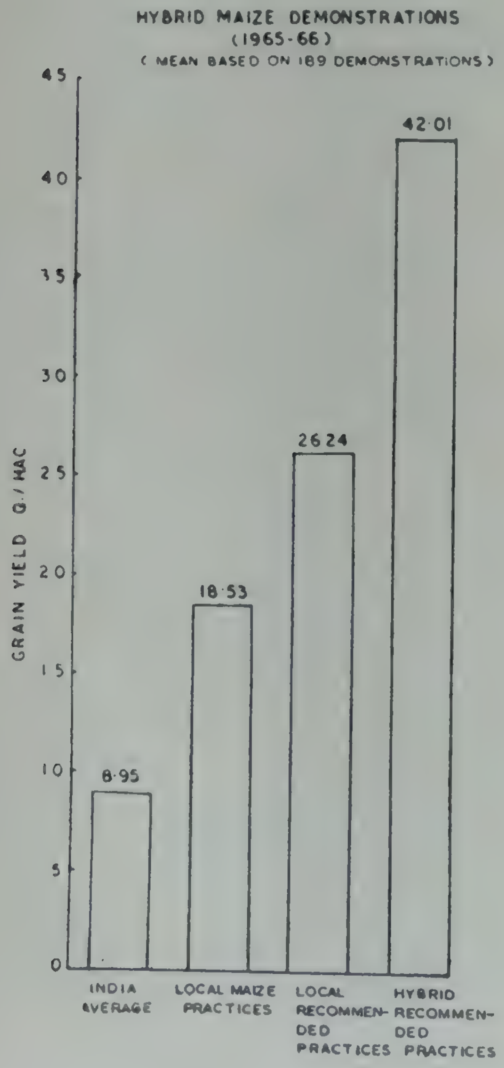
Yield, per unit area, is closely associated with effective plant population. The selection of plant types with ability to withstand higher population stresses would, therefore, markedly raise the yield levels. It has been shown that plants with short erect narrow leaves, sparsely branched tassel and high nitrate reductase activity will be better responsive to high population density. Research, with a view to developing high population responsive varieties has already been initiated.

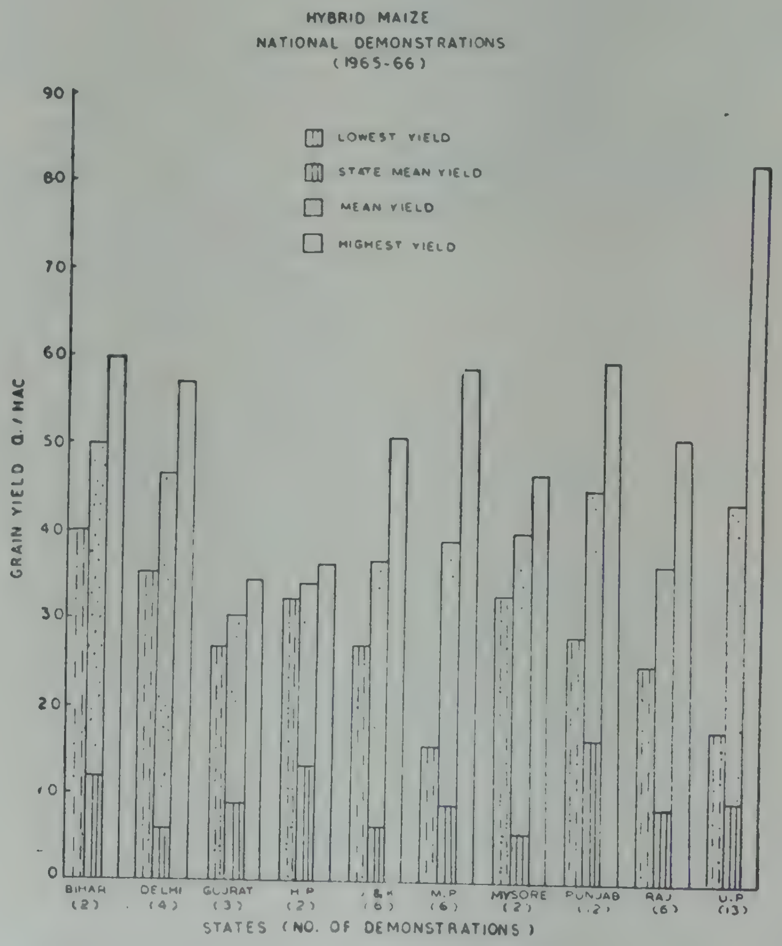
Lodging is a serious problem in the foot-hills and higher elevation areas of Himalayas. Of the several dwarfing genes which reduce plant height, brachytic-2 has been most promising. Even though, reduction in plant height even up to 60% or more, has been observed through the use of brachytic-2 in several genetic backgrounds but no marked improvement in yield over the normal tall types has yet been recorded. Some of the modified medium statured brachytic-2 selections with less telescoped leaves, however, suggest some promise.

Maize Husbandry

Traditionally, maize has been cultivated as a kharif crop, mostly under rainfed conditon. Total rainfall and its distribution pattern is fairly erratic and this frequently leads to either moisture stress or waterlogging. In the states of Bihar, Andhra Pradesh, Mysore and Tamil-Nadu, where the winter is mild, successful crop of maize can also be grown during rabi. In other states, spring maize when planted in February has proven very successful. Available data from Delhi, Andhra Pradesh, Bihar and Uttar Pradesh (Pantnagar) have suggested that 20-50% or more yields can be harvested from rabi and spring sowings than from kharif crop (Table 7). These observations have, in recent years, led to the increase in acreage under rabi maize in the states of Bihar and Andhra Pradesh.

Data of sowing also considerably influences the yield levels. Studies



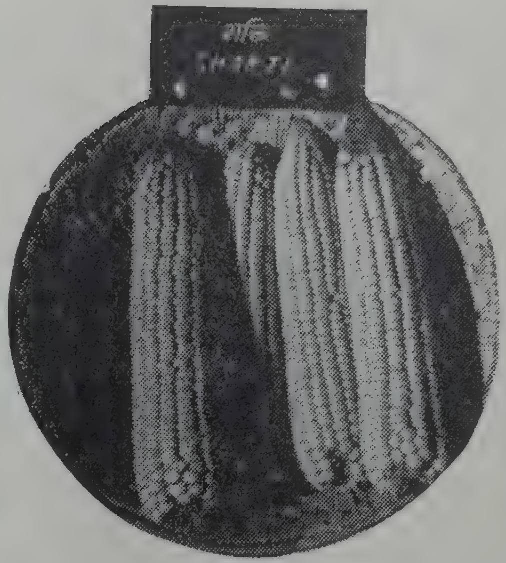


at several locations in the country have shown that planting when made 10-15 days before the usual normal planting dates gave 15-20% more yield. However, early planting can profitably be done by farmers who have adequate irrigation facilities.

High-yielding hybrids and composites have responded more favourably to fertilizer application than the local varieties. In general, most of the maize hybrids have responded economically up to 150-200 kg nitrogen/ha in contrast to the local varieties which have responded up to 50-75 kg nitrogen/ha. The precise level of response, however, would depend upon the previous cropping history of the field, chemical composition of the soil and the potential of the variety used. Economic response to the application of 50-60 kg/ha of P_2O_5 and up to 40 kg/ha of K_2O has also been obtained. Response to potash, in general, has been recorded from higher elevations. Among the micronutrients, zinc application has shown favourable response in areas with light soils and in fields where subsoil has been exposed during levelling. Significant response to zinc up to a level of 24 kg/ha has been recorded at certain locations in Punjab and Gujarat.

Most of the maize varieties grown in the Indo-Gangetic plains are of short-duration and have, therefore, found place in several crop rotations. Some of the commonly followed crop rotations in North India are: maize-wheat, maize-barley or maize-berseem. The high-yielding hybrids and composites of maize planted by the end of June or early July are harvested by end September to early October and thus provide adequate time for land preparation for rabi sowings. In North India high-yielding hybrid and composite varieties of maize also conveniently fit into maize-potato rotation, provided maize is planted in early June with irrigation.

Ganga 5 a high-yielding hybrid has shown wide adaptability in the Indo-Gangetic plains and Peninsular India.



Shakti, a nutritively superior opaque-2 composite recently released.

Plant Protection

Maize is prone to a number of diseases but the important among them are: leaf blight (*Helminthosporium turcicum* and *H. maydis*), brown stripe downy mildew (*Sclerophthora rayassiae* var. *zeae*)., brown spot (*Physoderma maydis*), rust (*Puccinia sorghi*), stalk rots (*Cephalosporium acremonium* and *Pythium aphenidermatum*) and bacterial stalk rot (*Erwinia carotovora* var. *zeae*). Most of the hybrids and composites released for cultivation have fairly high level of resistance to foliar diseases. Ganga 5 has marked resistance to leaf blight and brown stripe downy mildew. Ganga Safed 2, Deccan and Him. 123 have considerable resistance to leaf blight. However, hybrids like Ganga Safed-2 have also shown substantial resistance to

A farmer of Bangalore participates in the hybrid seed production. He has produced the male parent of Ganga Safed 2.

TABLE 1. CALCULATED GAINS IN BODY WEIGHT AT ICMR RECOMMENDED LEVELS OF PROTEIN AND CALORIES INTAKE IN THREE GROUPS OF CHILDREN FED WITH OPAQUE-2 AND SKIMMED MILK

	Opaque-2 Group grain in in body wt (gm)			*Skimmed Milk Group grain in body wt (gm)*		
Age group (months)	*in 60 days*	*Per day*	R^2%	*in 60 days*	*Per day*	R^2%
06–12	187	3.1	45 (i)	36	0.6	21 (iv)
13–24	229	3.8	21 (ii)	166	2.8	23 (v)
25–36	77	1.3	12 (iii)	354	5.9	11 (vi)

(i) $y = -294.7370 + 5.4275X_a - 0.0241X_c + 12.7200X_p$
(ii) $y = -242.1071 + 6.7919X_a - 0.1176X_c - 4.5518X_p$
(iii) $y = -75.3705 + 1.7008X_a - 0.0025X_c - 2.6572X_p$
(iv) $y = -217.9534 + 4.4120X_a - 0.3266X_c - 20.2703X_p$
(v) $y = -385.6345 + 6.1738X_a - 0.1250X_c - 1.8723X_p$
(vi) $y = -256.4752 + 1.2459X_a - 0.6035X_c - 10.4548X_p$
Where y = Grain in weight(Kg) body wt.
X_a = Attendance, X_c — Calories, X_p — Protein

stalk rots as well.

Sources of resistance to major diseases have also been identified. Currently used gene Ht 1 and a newly identified gene HtN are available as sources of resistance to *H. turcicum*. Cuzco stocks have shown marked resistance to maize rust, while CM 600, an Indian open-pollinated variety, is resistant to bacterial stalk rot. The inbred lines CM 104 and CM 103 are also resistant to yellow mosaic virus and Pythium stalk rot.

More than sixty different pests are known to attack maize but stem borers (*Chilo partellus* and *Sesamia inferens*) are most important in North India. Techniques for the mass rearing of the borers on synthetic diet have been perfected. A number of available maize varieties and hybrids have already been screened for borer resistance; collections like Antigua Gr.I, Barbados Gr.I and Caribbean flint composite have shown marked resistance to *Chilo partellus*. In addition to breeding for resistance, suitable chemical schedules have also been worked up; seed treatment with carbofuran or suitable sprays and granular application of lindane or endosulfan, etc. are promising.

More recently, efforts have been directed towards combining resistance to the important diseases and pests. Such resistant types, it is expected, shall not only reduce the cost of cultivation but would greatly help in stabilizing maize production in the country.

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NEW VISTAS IN COTTON PRODUCTION

Quarter Century of Progress

V. SANTHANAM*

COTTON has a pride of place among the commercial crops of India, being the prime supplier of raw material for the textile industry, which is the second largest in the world, being next in importance only to the textile industry of the United States of America.

The organised sector of the Cotton Textile Industry constitutes the largest single industrial segment in the country, in terms of annual value of output and labour employed both direct and indirect. There are 668 cotton textile mills in India now having an installed capacity of 18.1 million spindles and 209 thousand looms. The industry provides direct employment to nearly 900 thousand workers daily and indirect employment to several millions.

During the last 25 years, the industry has made steady progress (vide Table 1) with progressive increase in consumption of raw cotton which is expected to reach 66 lakh bales during 1972-73.

Area and Production

With about eight million hectares under the cotton crop, India ranks first in the world in respect of area and fourth in total production which is estimated to have reached the level of 65 lakh bales during 1971-72.

The production of cotton in the country has increased by nearly 155% during the past 25 years, viz., from 21.6 lakh bales in 1947-48 to an estimated 65 lakh bales in 1971-72, with an increase of 80% in the yield per unit area also during the corresponding period.

Past Achievements

Since the inception of the first Five-Year Plan in 1951, the erstwhile Indian Central Cotton Committee granted funds to the State Departments of Agriculture for implementing a number of schemes for developing better varieties of cotton and extending their cultivation through seed multiplication and development schemes. Breeding of new varieties is a continuous process and improved strains evolved in the earlier years have been replaced progressively by still better varieties.

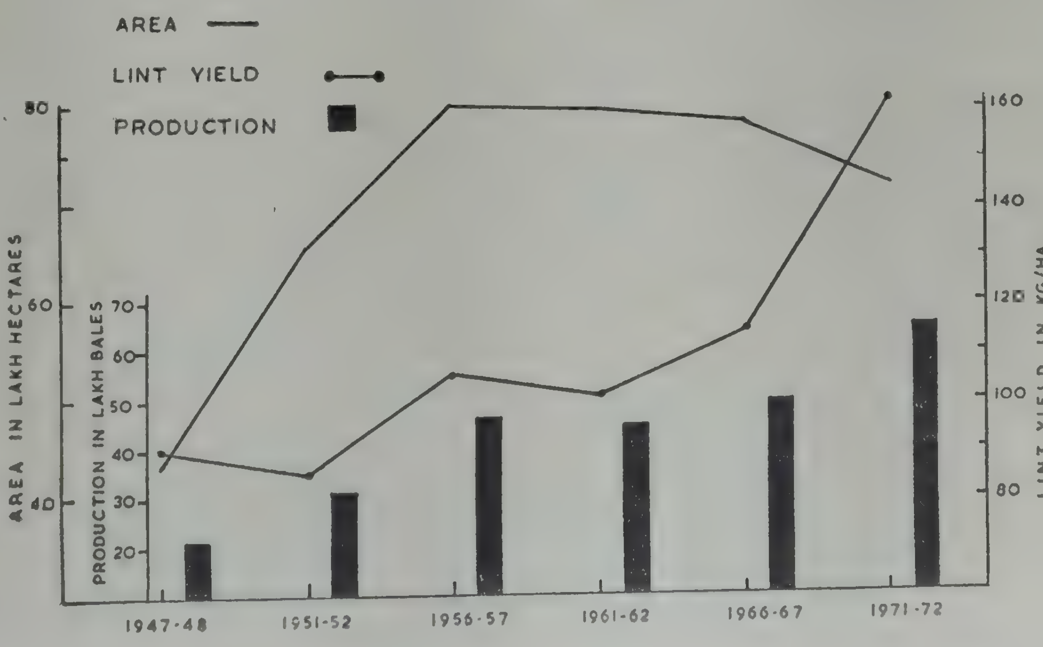
During the first Five-Year Plan, 11 new improved cotton varieties were released for general cultivation in the various tracts in India. Out of these, 320-F in Punjab, H-14 in Haryana, Deviraj and Digvijay in Gujarat and MCU-2 in Tamil Nadu are noteworthy. The notable strains released during the second Plan in different States are Badnawar-1 in Madhya Pradesh, Buri-147 in Maharashtra and MCU-3 in Tamil Nadu. During the third Plan period, varieties Gujarat-67 and Buri-1007 among others were released for general cultivation. The evolution and spread of these improved strains has helped the Indian Cotton Textile Industry to rely more and more on indigenous production for better quality raw material.

All-India Coordinated Cotton Improvement Project

When the Indian Council of Agricultural Research took over the research functions on various crops from the erstwhile Central Commodity Committees in 1966, the Council inherited the high traditions of the Indian Central Cotton Committee. Many of the important schemes of

Fig. 1. Area and production of cotton

FIG 1.



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*Project Coordinator (Cotton) & Head, I.A.R.I. Regional Station, Coimbatore.

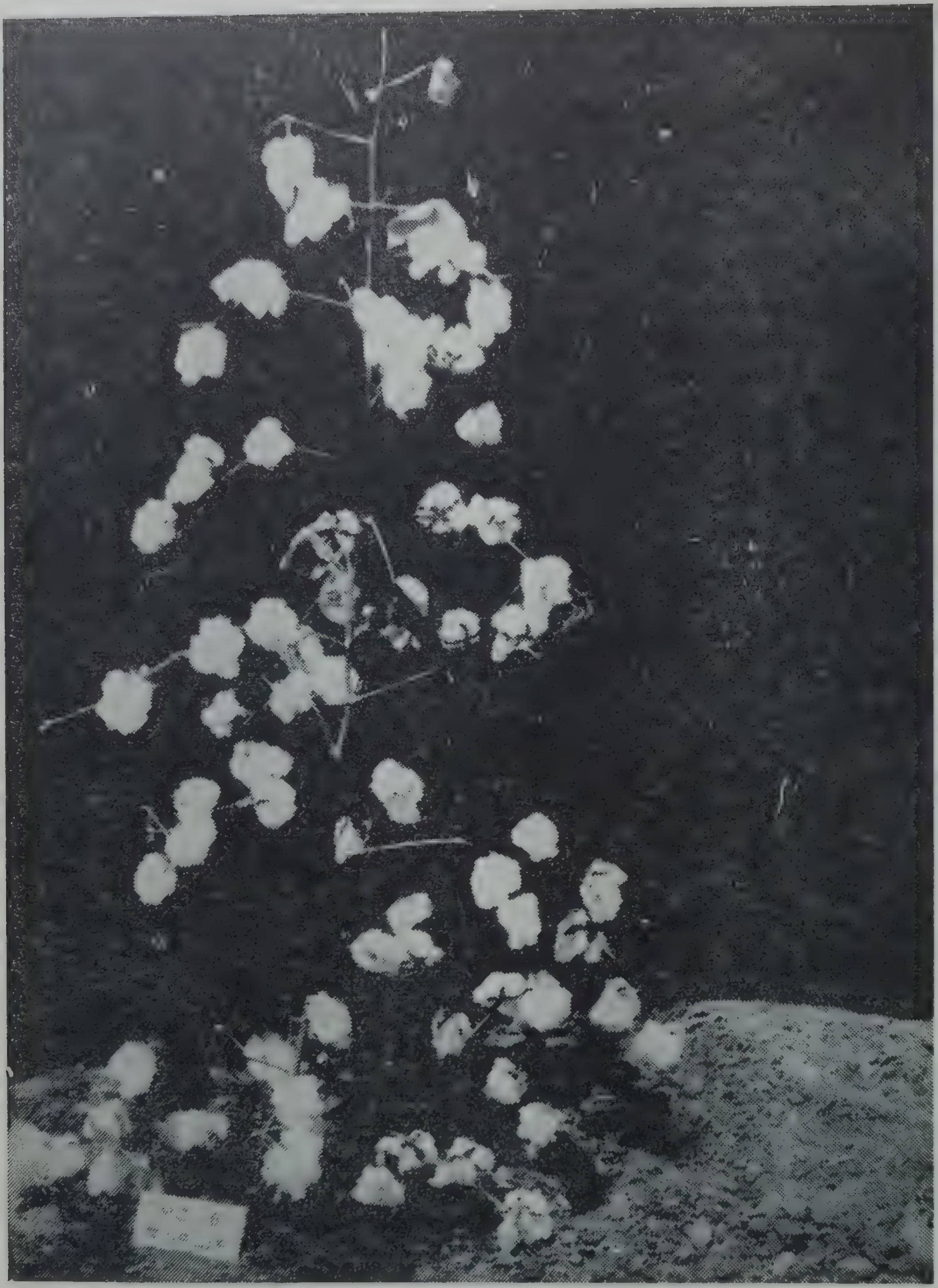


Fig. 2. MCU-5

cotton research were merged with the All-India Coordinated Cotton Improvement Project sponsored by the Council in 1967 and the research programme on cotton has since been intensified.

The main objective of this Project is to evolve better-yielding varieties of cotton in the various quality groups, suitable for different tracts and develop improved agronomic practices and crop protection schedules for realising high yields from the newly released varieties.

The research programme under this Project is now carried out in 11 Main Centres, 19 Sub-Centres and 30 Testing Centres located in the Agricultural Universities, State Departments of Agriculture and the Central Research Institutions, in the principal cotton growing States.

Recent Progress in Research

As a result of intensification of the research work, the following fifteen new varieties of cotton have been released for cultivation during the past five years.

1968

1. Variety 'KRISHNA'. Released in the rice-fallows tract of Andhra Pradesh replacing variety P. 216-F cultivated earlier. The new variety combined higher yield and better fibre and spinning quality as compared to P. 216-F.
2. Variety 'MCU-5': Released in the irrigated winter Cambodia tract in Tamil Nadu replacing varieties MCU-1 and MCU-3 cultivated earlier. This is the best *hirsutum* variety so far developed and released in India with a staple length of 1-3/16" and spinning value of 60s-70s counts. This variety is suitable for replacing imported Sudan cotton of equivalent quality.

1969

3. Variety 'KHANDWA-1'. Released in the Nimar tract of Madhya Pradesh replacing earlier variety A 51-9 (Narbada). The new variety which is equal in yield to Narabada is significantly superior in fibre quality with 43s H.S.C. spinning capacity as compared to 34s of Narbada.
4. Variety 'G-27'. *Desi* variety released in Punjab and Haryana in place of 231-R. The new variety is significantly better in yield (22% increase) with the same fibre quality.
5. Variety 'SUJATA'. Released in the irrigated cotton tracts in Tamil Nadu. This is the first Egyptian type of cotton released in India with the highest spinning value of 80s-100s counts. This is suitable for replacing imported Egyptian cotton of equivalent quality.
6. Variety 'BHARATHI'. *Hirsutum* strain released in the Karunganni tract of Tamil Nadu, replacing the existing *desi* variety K-7. This new variety recorded almost twice the yield of

desi variety and possesses better spinning value.

1970

7. Variety '1301-DD' (Mahalaxmi). Released in rainfed areas of the Northersn tract of Andhra Pradesh replacing Laxmi. This has recorded 20% to 30% higher yield than Laxmi, possesses better tolerance to jassids and is equal to Laxmi in spinning quality.

1971

8. 'HYBRID-4': Hybrid-4 cotton developed at Surat in Gujarat, with appreciably higher yields as compared to earlier variety Gujarat-67, has been found to be widely adapted. The yields obtained from Hybrid-4 in fields of cultivators are very high ranging from 25 to 50 quintals per hectare.
9. Variety '3943'. *Herbaceum* variety released in the South Gujarat cotton tract in place of Digvijay. The new variety recorded 30% higher yield over Digvijay with better ginning out-turn and satisfactory fibre and spinning quality.
10. Variety 'KHANDWA-2'. *Hirsutum* variety released in the light soil areas of Nimar tract in Madhya Pradesh to replace *desi* variety Maljari. The new variety is shorter in duration maturing in 150 days, significantly higher-yielding than Maljari and with better fibre and spinning properties.
11. Variety '1143-EM'. (Named MCU-7). Released in the medium duration rice-fallow tract of Tamil Nadu replacing P. 216-F. The new variety gave on an average 30% increased yield over P. 216-F with significantly higher spinning performance.
12. Variety 'K-8'. Karunganni variety released in the rainfed black-soils of southern districts of Tamil Nadu replacing earlier variety K-7. The new variety gave 23% increased yield of lint over K-7 with slightly better spinning performance.

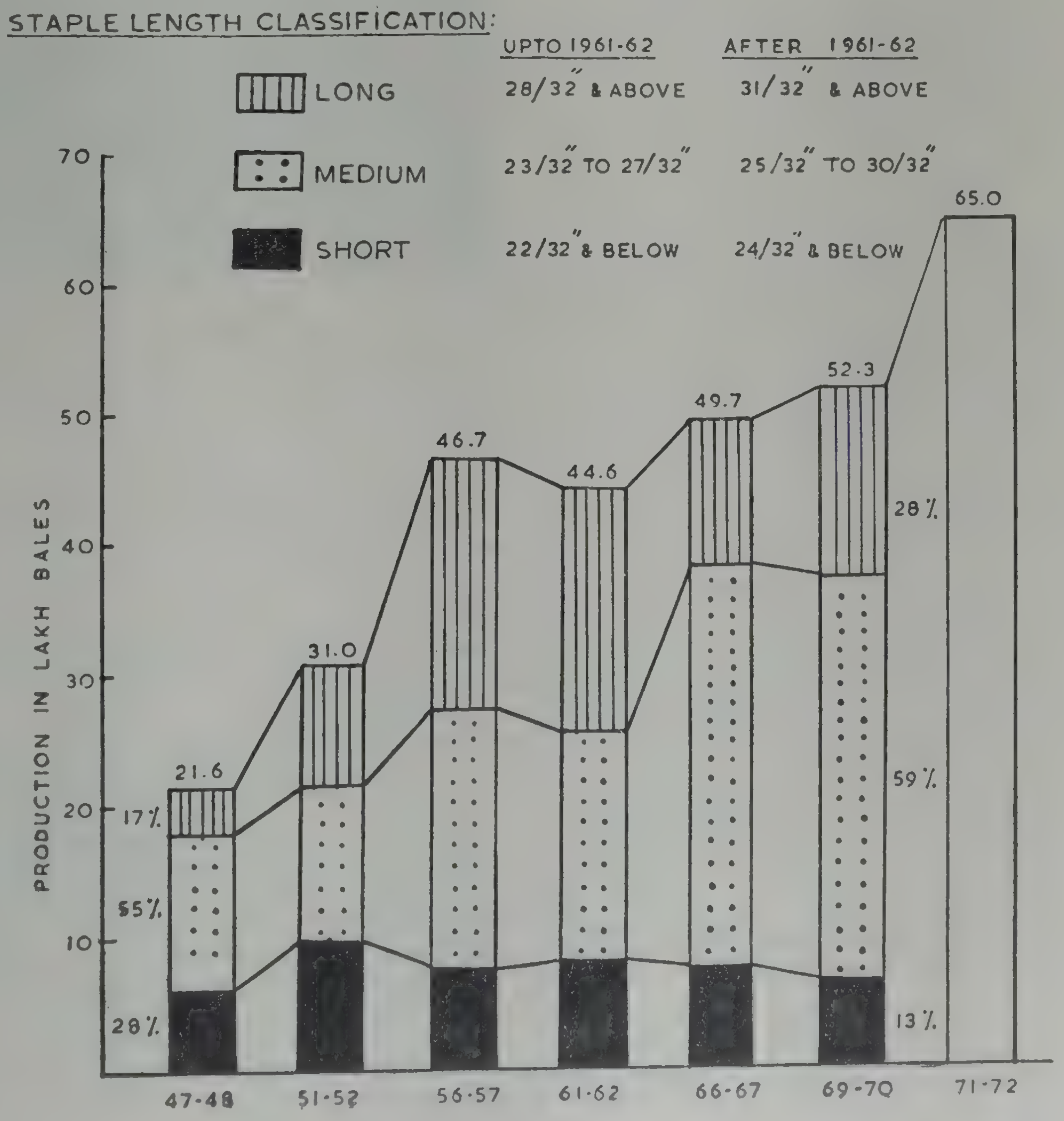
1972

13. Variety 'RS-89'. *Hirsutum* variety released in Sriganganagar tract of Rajasthan to replace variety 320-F. The new variety gave 21% increased yield, was earlier in maturity by 10 days and is distinctly superior in fibre and spinning quality to variety 320-F, with a performance of 48s H.S.C. as compared to 34s of 320-F.
14. VARALAXMI. Hybrid, Hybrid cotton released in the Tungabhadra Project area in Mysore State; has an yield potential of 30 to 38 q/ha, seed cotton; has been found suitable for spinning up to 60s counts.
15. Variety 'GS-23'. *Hirsutum* variety released in the lower rainfall tracts of Mysroe State to replace Laxmi cotton; recorded an increase of 11% in yield of *kapas* with outstanding ginning outturn of 39% to 42% as compared to 29% to 34% of variety Laxmi.

Significant Milestones

Out of the above, the release of *hirsutum* variety MCU-5 and Hybird-4 cotton constitute significant milestones in cotton research. Variety Sujata is the highest spinning

Fig. 3. Quantitative and qualitative improvement in cotton production



cotton so far releasd in India. The spread of Hybrid-4 cotton has made great impact on production during 1971-72 and the quality of the crop has been significantly stepped up by MCU-5. Apart from the above varieties, which have already been released, a number of promising varieties have been built up to meet the requirements of different zones in the various quality groups They are expected to be released during the next two to three years. They have been indicated in the list of improved varieties in Table 2.

Apart from the release of new varieties, improved agronomic practices and plant protection schedules for adoption in the different tracts have also been developed.

The new varieties suitable for spinning various count groups of yarn and the improved agronomic and crop protection techniques form the basis for the new strategy now adopted for increasing cotton production in the country, through the implementation of the Intensive Cotton District Programme sponsored by the Government of India since 1971-72.

There has been progressive improvement in cotton production both quantitatively and qualitatively consequent on the release and spread of the new better-yielding varieties of cotton in the various quality groups during the past two decades.

Future Thinking and Long-term Approach

The demand projections for raw-cotton based on population increase, rising standards of living, exports of cloth, yarn and raw-cotton, and extra-factory consumption in the country, have been computed as follows during the next twenty years.

Requirements of raw cotton during 1974-1994.

The mills' qualitative requirements of cotton by the end of the

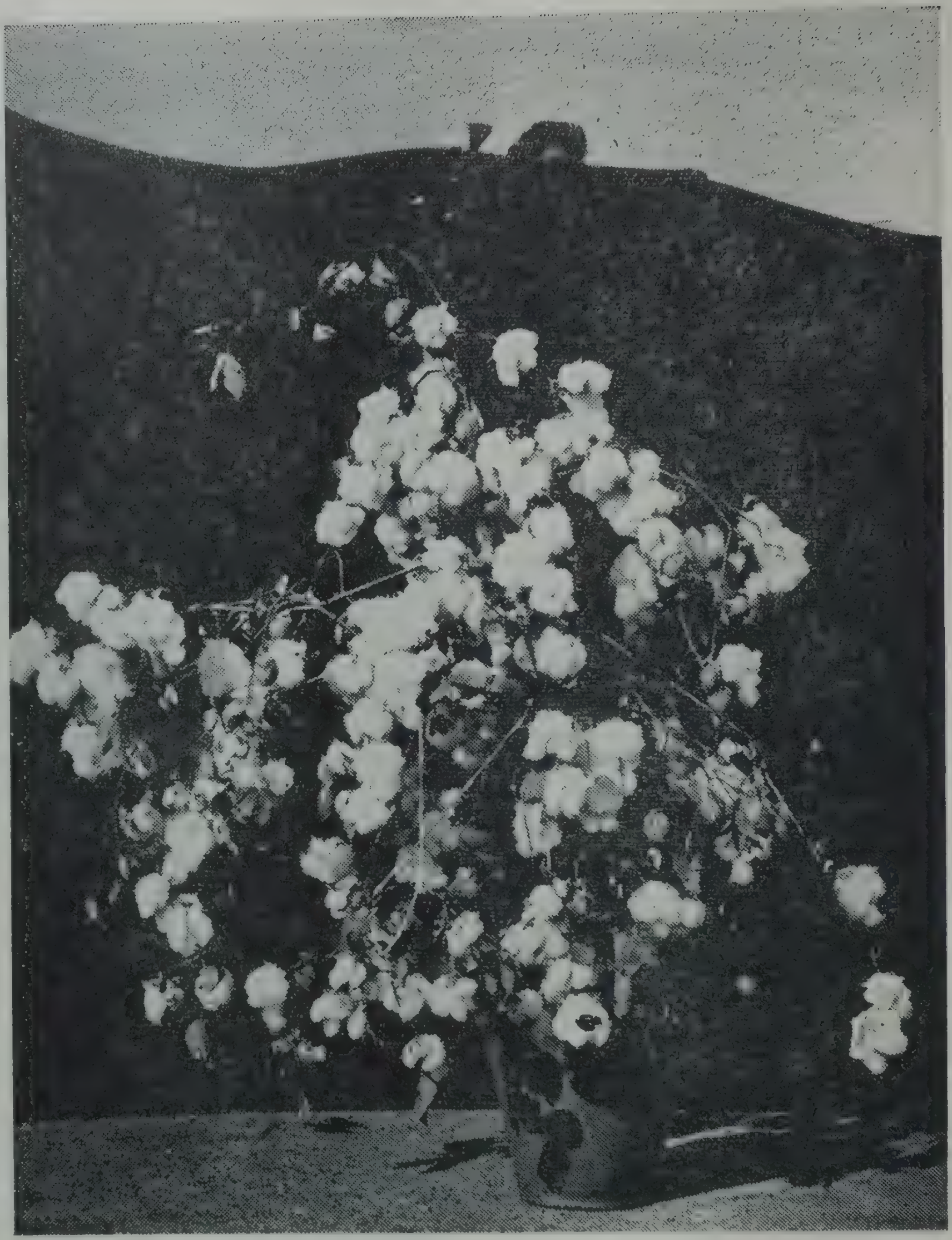


Fig. 4. Hybrid 4 cotton with phenomenal yield potential

REQUIREMENTS OF RAW COTTON DURING 1974–1994

		Projections		
		1973–74	*1983–84*	*1993–94*
1.	Population in millions	596	715	801
2.	Cotton cloth requirements million metres (assuming growth of 2% over 13.7 m. per capita)	8,165	11,726	15,780
3.	Raw cotton required to produce the above quantity at 7.2 metres per kg. of cotton (lakh bales)	63	90	122
4.	Total cotton required by the country in lakh bales (Adding 25 per cent for exports of cloth, yarn, raw-cotton & extra-factory consumption)	79	113	153
5.	Lint yield (kg/ha.) to achieve the above production, without increase in area.	178	254	344

Fourth Plan have been assessed as 3.5 lakh bales of short staple, 26 lakh bales of medium staple, 32 lakh bales of superior medium staple, 14.5 lakh bales of long staple and 4 lakh bales of extra-long staple cotton, thus making up a total of 80 lakh bales to be produced by the end of the Fourth Plan.

It is anticipated that in a humid tropical country like India, the comfort factor provided by cotton will have natural advantage over man-made fibre fabrics. Nevertheless, increase in the consumption of man-made fibres would be more in terms of blended fabrics and it is therefore anticipated that during the next two decades, the qualitative break-up of the total demand projection, would be in the same proportion as it obtains at present. It is further assumed that any substantial increase in consumption of fabrics due to rising standards of living, might be made up by man-made fibres and that this will not be at the cost of the present per capita consumption of cotton.

The production programmes oriented towards achieving the above goals for self-sufficiency in raw-cotton both quantitatively and qualitatively, would be adequately backed by a strong research base provided by the Indian Council of Agricultural Research.

Acknowledgements: The results of research and breakthrough in cotton cultivation reviewed in this paper are the outcome of co-operative endeavour by a number of workers all over the country.

TABLE 1. GROWTH OF THE INDIAN TEXTILE INDUSTRY AND CONSUMPTION OF COTTON

Year	*No. of Mills*	*Installed spindles (in millions)*	*Consumption of cotton in lakh bales of 180 Kg. each*		
			Indian	*Foreign*	*Total*
1947	356	10.07	32.12	7.15	39.27
1952	383	11.25	31.95	10.12	42.07
1957	436	12.49	46.03	5.63	51.66
1962	481	13.83	47.09	9.79	56.88
1967	609	16.67	51.82	5.81	57.63
1970	656	17.67	56.57	7.14	63.71

TABLE 2. MAIN IMPROVED VARIETIES RECOMMENDED FOR CULTIVATION

Staple length classification (inch)		*Released varieties*		*Varieties likely to be released*	
		New world species	*Asiatic species*	*New world species*	*Asiatic species*
Short	24/32 & below	—	Ganganagar–1, G.27, Shyamali	—	Lohit, G.57
Medium	$\frac{25-27}{32}$	L.S.S., Hampi, G. Indore–1	Maljari, Coconadas-2	Jai	—
Superior medium	$\frac{28-30}{32}$	320–F, H.14, J.34, Pramukh, Narbada, Khandwa-2, Laxmi, Mahalaxmi (1301-DD), P.216-F, G.S.23.	V.797, Digvijay, Sanjay, 3943, Y. 1, Gaorani-46, AK.235, AK.277, Jayadhar, Suyodhar, Nandicum, Adonicum	J.205, S.S. 265, JK.97	S.3087, 355-E.6
Long	$\frac{31-33}{32}$	Deviraj, Badnawar-1, Khandwa-1, B.1007, B.147, Laxmi (I), MCU-1, PRS-72, Bharathi, MCU-7, R.S.89	K-7, K-8	H.297, PS.10, S.S.167, R.S.79, Reba B-50	—
Superior long	$\frac{34-37}{32}$	Hybrid-4, Varalaxmi, Krishna, MCU-2	—	C.P.1998-F, C.P.15/2	—
Extra-long	1-3/16 &above	Gujarat-67, S 1 Andrews, MCU-4, MCU-5, Sujata	—	P.S. 16, IAN-579 (188), Suvin, E.L. 0162	—

RECENT ADVANCES IN HORTICULTURAL RESEARCH

G. S. RANDHAWA
Director
Indian Institute of Horticultural
Research, Bangalore

The Indian Institute of Horticultural Research at Hessaraghatta has the broad objectives of conducting basic and applied research in horticultural science so as to tackle the problems involved in the successful production of horticultural crops and in the improvement of qualities of the produce for national and international markets. Recognizing the need for interdisciplinary approach for the ultimate success in solving problems of horticultural crops, the work of the three crop divisions of the Institute, viz. Fruit Crops, Vegetable Crops and Floriculture and Landscape Gardening are being actively supported by other disciplines such as, Entomology, Nematology, Plant Pathology, Plant Physiology, Biochemistry, Microbiology, Agronomy, Soil Science and Statistics. Three Horticultural Experiment Stations at Gonicoppal, Chethalli and Appangala in Coorg district of Mysore State have been transferred to this Institute by the Mysore State Government recently.

The Institute is one of the main centres under All India Co-ordinated Research Projects on Fruits, Vegetables, Spices, Floriculture and Mushrooms. On grape, mango, pineapple and vegetables, work has already been initiated. Under the All India Co-ordinated Project here the work on citrus, banana, pineapple and papaya is being co-ordinated at various centres within the country. A Dioscorea Improvement Project is also in operation in collaboration with Ford Foundation and Council of Scientific and Industrial Research.

Fruit Crops

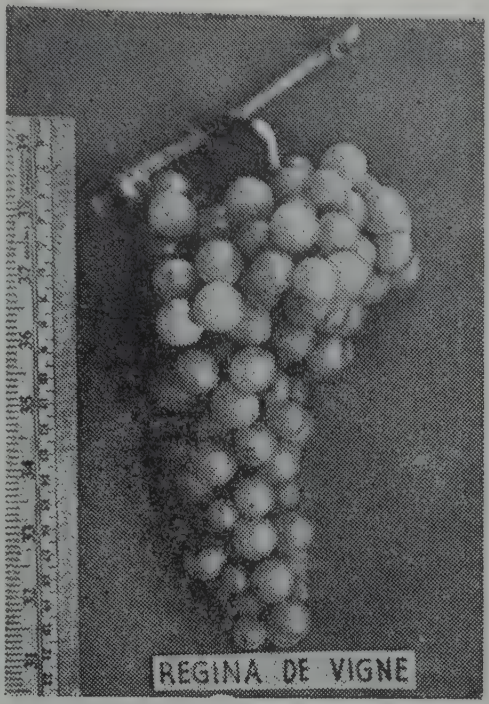
Screening of the genetic stock in grapes has enabled to isolate seven superior varieties, namely, Black Champa, Angur Kalan, Coarna Resia, Taifi Rosovi, Regina de Vigne, Convent Large Black and Katta Kurgan which have combinations of good yield and superior quality for table use. In mango, hybridisation has been undertaken with the aim of combining high productivity and stability in production with that of good quality of different varieties. In guava, the main emphasis on breeding has been the development of seedless varieties with attractive pulp colour. Breeding work in strawberries has enabled the isolation of four superior selections which have combined features of good fruiting, along with high runnering ability. These are now under

Ethrel treated pineapple Kew showing elongated fruits desirable for canning

trials and offer possibilities to be released as new varieties especially suited for plains. The assessment of genetic stocks of banana has revealed the high potentiality of the 'Robusta' banana for this area. This export variety has attractive bunches with high yield under high fertility level.

In Coorg Honey Dew papaya, the manurial dose consisting of 250 g of nitrogen, 250 g of phosphorus and 500 g of potash in the form of ammonium sulphate, superphosphate and muriate of potash per plant per year proved to be the best. In case of 'Robusta' banana a fertilizer mixture comprising of 180 g nitrogen, 180 g phosphorus and 225 g potash per plant is recommended. With this mixture a yield of 44 tons/hectare was obtained. A comparison between two spacings resulted in an yield of 47.57 tons/hectare and 37.87 tons/hectare in case of 2.4× 1.8 metre and 2.4× 2.4 metre spacing respectively. Spacing-cum-fertilizer trials in case of pineapple have revealed that it is possible to increase the plant density up to 43,500 per hectare in variety Kew using a distance of 30×60×90 cm. The best dose for this planting density has been found to be 12 g of N and 2.5 g of K per plant. With this combination a crop yield of 87 tons/hectare was obtained.

Post-harvest berry drop in Cheema Sahebi grape was best controlled with 50 ppm of NAA and next best treatment was 50 ppm NAA+250 ppm N^6-benzyladenine. Preliminary studies have indicated that sprays of Racuza (Methyl-3 6-dichloro-0-anisoate) at 400 ppm increased the T.S.S. in Anab-e-Shahi grape from 16.1% to 18.4% when applied one month before harvest. Ethrel at 25 ppm in combination with urea (2%) and calcium carbonate (0.4%) induced more than 90% flowering in Kew pineapple when applied to 12-month old plants. Flowering was induced within 50 to 60 days after application. Recently, ethrel has been used successfully in converting off year bearing Langra trees into on year. This is a major breakthrough and further work on this aspect is now being intensified.

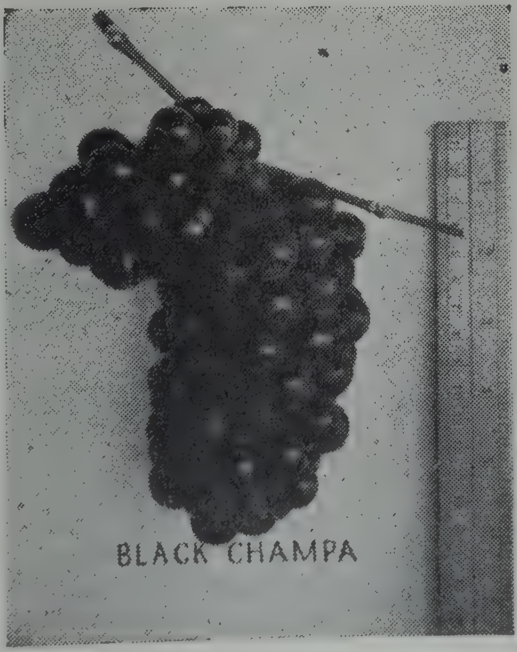


The grape variety Regina-de Vigne is superior for table and vine purposes

Vegetable Crops

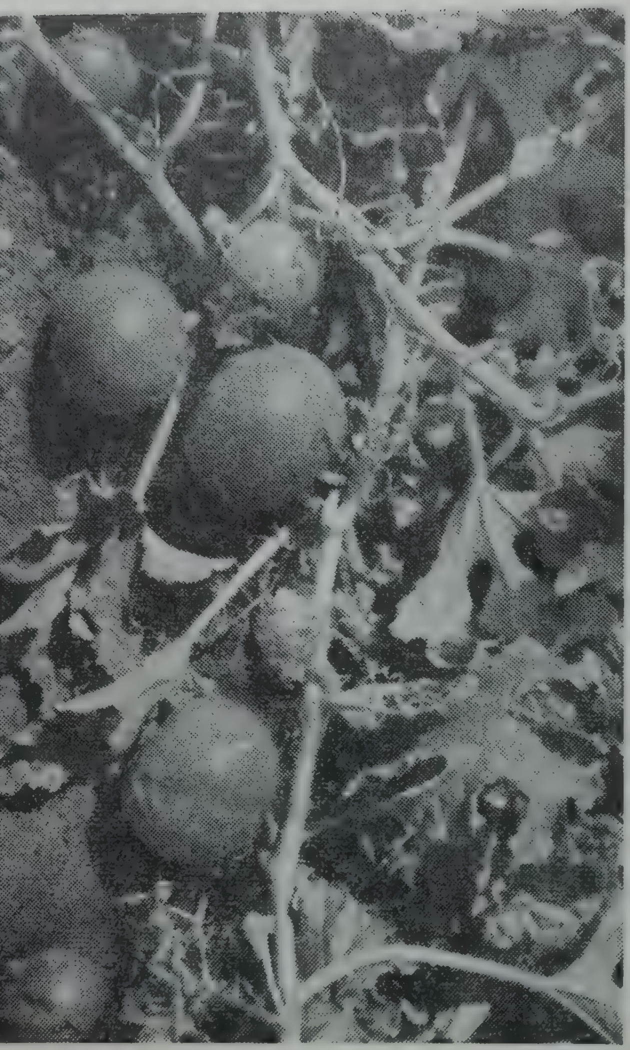
As a result of the intensive breeding programme undertaken in this Division, new varieties of pumpkin, muskmelon, *tinda*, hybrid watermelon and squash have been developed and released. *Arka Suryamukhi* is the first variety of pumpkin resistant to fruit fly. It has economy size fruits with good keeping, transport and cooking qualities. In muskmelon two varieties, namely, *Arka Rajhans* and *Arka Jeet* have been developed. *Arka Rajhans* is highly resistant to powdery mildew and has the yield about three times of the local strain. It has an excellent keeping and transport quality too. *Arka Jeet* is relatively dwarf variety having small attractive fruits of excellent flavour. It has 15-16% TSS with high vitamin C content (41.6 mg,100 g fresh wt.).

The promising grape variety Black Champa has superior quality and high yield



Arka Tinda, a high-yielding variety of newly introduced vegetable *tinda* in this region, has been developed which is tolerant to common fruit fly. A new hybrid watermelon, *Arka Jyoti*, with excellent quality and high yield has been evolved recently for the first time in this country. It produces about three times the yield of local strains and about 60 per cent more yield than the better parent. It has crimson flesh colour and very good keeping and transport quality. In bush squash, the American variety *Patty Pan* has been recommended as a high-yielding and short-duration variety for this region. It showed excellent performance with regard to quality and yield both in summer and rainy seasons.

A new line of okra, IHR 20-31 has been found to have good quality and high yield along with high tolerance to yellow vein mosaic virus. The rare amphidiploid between the cultivated and the yellow vein mosaic virus immune wild okra has been obtained to help breeding virus resistant variety of okra. Some very useful lines have been developed in dark purple long (IHR-192-1) and light green long (IHR 193-1 and IHR 194-1) brinjals for high yield and good quality. In bittergourd IHR-4 and IHR 37 have been found to have superior quality and yield. Another pumpkin line IHR 105-1 with high yield and carotene content



A high-yielding variety Arka Tinda evolved at the Institute

is under large scale trials. In radish, white rust resistant line has been isolated.

Floriculture and Landscape Gardening

One hundred and thirty varieties of *Hibiscus rosa-sinensis* were collected and large number of crosses were made in 65 different parental combinations. Out of 500 seedlings of hybrids, 26 hybrid plants were selected on the basis of their better performance. The Institute has an unique collection of crotons and as many as 1200 hybrids have been developed. These are under scrutiny and several colourful hybrids are likely to be released shortly.

Seventy varieties of bougainvilleas were collected from various sources and a large number of seedlings were raised from the open-pollinated seeds. A large number of varieties have also been collected in rose, jasmine and orchid for improving their quality by breeding methods and suitable agro-techniques.

Plant Physiology, Biochemistry and Microbiology

The chemical weed control programme of the division has yielded very useful results. Bromacil at the rate of 3 kg/ha in the form of pre-emergence spray has proved effective in controlling most of the broad leaved weeds and grasses in pineapple fields. In vineyards, Atrazine at the rate of 3 kg/ha and Simazine at 4 kg/ha have given very encouraging results and were able to give a complete control for about four months and a reasonably good control for a year.

In sapota, Diuron and Bromacil at the rate of 3 kg/ha have been very effective in controlling broad leaved weeds as well as grasses. In banana, variety Dwarf Cavendish, Diuron at 4 kg/ha proved to be very useful in controlling most of the broad leaved weeds and grasses for six months. Lasso at 91/ha+Diuron 2 kg/ha also effectively controlled the weeds.

In French bean variety Contender, Lasso at 3 kg/ha and Amiben at 2 kg/ha proved to be the best in controlling both broad leaved weed and grasses. A significant increase in yield was also noticed in these two cases. In tomato, Lasso at 1 kg/ha checked the broad leaf weeds and most of the grasses.

While standardising the maturity standards in banana based on the biochemical changes associated with growth and development of fruits, it has been recommended that Dwarf Cavendish banana should be harvested any time between 115 days and 130 days of fruit growth to obtain best quality and yield.

Plant Pathology

A fungicidal experiment on sapota has shown that Dithane Z-78 (0.2%). strength was very effective in controlling the leaf spot disease. The fungicidal application gave a net profit of Rs 24.00 per tree over control.

One of the major diseases of guava, the Phytophthora fruit rot could be effectively controlled by the application of Dithane Z-78 (0.2%) and Aureofungin (10 ppm). Dithane sprayed trees gave the highest yield of 184 kg per tree against 125 kg in control. All the copper fungicides, viz., Blitox, Fycol 8E and Fytolan were toxic and caused russetting on the fruits. Spraying with Dithane Z-78 was economical.

Powdery mildew of mango could be effectively controlled by giving fortnightly sprays of Cosan (0.2%) during the months of January to May at Bangalore.

Chemical control trials on grapes have shown that the downy mildew disease could be effectively controlled by spraying either Fycol 8E, (1.0%) Blue Copper (0.3%) or Blitox

A high-yielding good quality hybrid water melon variety—Arka Jyoti evolved at the Institute

(0.5%) at an interval of 3 to 4 days during humid weather and at weekly intervals during the remaining period of the year. Weekly sprays of Difolaten (0.3%) gave good control of anthracnose disease.

Powdery mildew of peas was effectively controlled by spraying with Cosan (0.2%) and Benlate (0.1%). Fortnightly sprays of Karathane (0.03%), Cosan (0.2%) or Benlate (0.1%) gave good control of powdery mildew of okra.

Field trials carried out with eight different insecticides (systemic and contact) to control the whiteflies, *Bemisia tabaci* Gen. the vector of yellow vein mosaic of okra, revealed that Ekatox, Rogor, Dimecron and Thimet were effective not only in reducing the population of whiteflies but also in reducing the incidence of the yellow vein mosaic virus to 5, 6, 10 and 19 per cent respectively as compared to 76 per cent incidence in unsprayed control plots.

Regular application of systemic insecticides such as Rogor (0.05%), Ekatox (0.02%), Metasystox (0.02%), Thimet (15 kg/ha) and Dimecron (0.05%) starting from seedling stage not only reduced whitefly population in tomato from 65 to 13, 16, 20 and 20 for every seventyfive leaves counted but also reduced the incidence of the tomato leaf curl virus from 16.5 to 1.6, 2.5, 2.6, 4.6 and 6 per cent respectively in the variety Pusa Ruby. The storage rot of banana was effectively controlled by the application of Benlate (0.2%).

The European mushroom was grown successfully in an exploratory trial carried out during September-December months. The spawn has been multiplied for distribution.

Entomology

Among vegetables, tomato is an important crop which is damaged by fruit borer. It has been effectively controlled by spraying Fenitrothion (0.08%) or Carbaryl (0.2%). Aphid on pea is a common pest in this region which has been controlled by a single application of Furadan and Cytrolane granule at the rate of 1.5 kg/ha or by Spraying Dimethoate 0.5 kg/ha twice. The pod borer of Okra has been controlled by the spray of Carbaryl (0.2%) at 10 days interval. It has a very short residual effect.

Pineapple crop is commonly effected by mealy bug and preliminary experiments on its control suggests that the application of Thimet at the rate of 17 kg/ha on alternate months keeps the crop free of the pest. Litchi mite damage has been a limiting factor in the cultivation of litchi in certain regions. This pest has been effectively controlled by the monthly spray of Kelthane (0.125%).

Nematode is another important pest. Extensive surveys have been conducted and those attacking grape, pineapple, banana have been collected and are being identified. In tomato, few lines resistant to nematode have been isolated.

Agronomy and Soil Science

Based on the results of nutritional trials conducted so far, the optimum levels of NPK for the various vegetable crops are given below.

Tomato. Under the existing price situation of fertilizer and produce, the optimum level for tomato (Pusa Ruby) was specified as 115 kg N+104 kg P_2O_5+61 kg K_2O/ha giving fruit yield of 35.2 tonnes/ha.

Muskmelon. With Arka Rajhans, the optimum level was found to be 106 kg N+84 kg P_2O_5+40 kg K/O_2 ha yielding 24.16 tonnes of ripe fruit per hectare.

It has also been found that this variety of muskmelon should be sown in rows 2.4 m apart with 2 plants per hill at 0.9 m distance within the rows.

Pumpkin. Optimum level of fertilization for pumpkin var. Arka Suryamukhi was found to be 103 kg N+106 kg P_2O_5+40 kg K_2O/ha for summer crop and 96 kg N+88 kg P_2O_5+40 kg K_2O/ha for rainy season crop yielding 31.76 and 14.34 t/ha respectively.

Okra. The optimum level for Pusa Sawani was specified as 119 kg N+88 kg P_2O_5+ kg K_2O/ha yielding 13.43 t/ha of fruits.

Dioscorea Improvement Project. Tubers of wild Dioscorea contain a steroid diosgenin which is used in the preparation of a number of steroid hormones including the oral contraceptive pill. Screening of hundreds of clones in Deltoidea and Floribunda species for diosgenin content showed a range of 1.6 to 8.3% on dry weight basis. Studies on the yield and diosgenin content of clones harvested after every year's growth enabled to select a few clones of deltoidea with as high as 6 to 6.7% diosgenin and a tuber yield of 800 to 1,130 gm. Interspecific hybridisation has also been taken up with a view to increase the tuber yield and diosgenin content. A number of field trials to standardise the agro-techniques including quick propagation methods for the domestication of this plant are also being taken up. In *D. floribunda* yield up to 6 kg in 22 months with chemical between 4 to 5 per cent has been obtained. This species has proved very promising under Hessaraghatta conditions.

Citrus Experiment Research Station, Gonicoppal. This research station was started nearly 25 years ago with the objective of probing into the causes of decline in mandarin orange and to evolve control of this malady. For this purpose studies on various aspects like nutrition, rootstocks and disease and pest control were undertaken. Evaluation of 250 species, varieties and strains of citrus from all over the world showed that the scion varieties Washington Navel, Valencia, Pineapple, Seedless Unshiu and Seedless lime are less susceptible to die-back. Based on up to date results of the extensive rootstock trials the rootstocks Rangpur lime, Trifoliate, Kodakithuli, Cleopatra mandarin, Troyer citranges and Rough lemon have been found promising for Coorg mandarin and resulted in considerably less decline and more yield. This is being practised on large scale in the citrus growing region of Coorg. A number of micronutrient experiments have revealed that the spray of zinc and copper can effectively reduce chlorosis in mandarin. The results of manurial trial have already demonstrated the need of balanced manuring in mandarin plantations in order to reduce the incidence of die-back disease. Efforts have also been made to suggest values of various macro and micro-nutrient levels in the leaves on the basis of leaf analysis. The various insect pests and diseases causing damage to citrus plantations have been identified and efforts are afoot to control these pests.

Horticultural Experiment Station, Chethalli. The prime objective of the station was to find out the adaptibility of various tropical, sub-tropical, adaptibility of humid tropical and temperate crops of India, their nutritional and cultural requirements and pest control measures. Citrus rootstock trials with 29 rootstocks have revealed the superiority of rootstocks viz. Rough Lemon, Kodakithuli and other trifoliate stocks as was observed at Gonicoppal. Fertilizer and irrigation trials have revealed that nitrogenous manure and irrigation once a week give best response in respect of vigour and crop production.

The outstanding achievement has been the development of a new papaya variety Coorg Honey Dew which has very good fruit quality and high yield. The main characteristic of this variety is that the plant is dwarf at the first fruiting stage and the flowers are hermaphrodite or female ensuring that every plant will bear fruits. This solves the problem of putting more seedlings at planting in order to rogue out more of male plants at the flowering stage only which are unproductive.

Horticultural Experiment Station, Appangala. This station was started during 1960 with the objective of conducting researches on spice crops suited to the Malnad conditions prevailing in Coorg and its neighbouring spice-growing tracts. Among the varieties tested for their performance the cardamom varieties Hema 4 and Serial No. 57, the ginger varieties, Rio-de-Janerio and China and the hybrid varieties of Red Oil Palm Dura × Dura, Dura × Pesifera and Dura × Tenera has performed better than other varieties. In the manurial trial for cardamom it was found that the plants receiving 125 gm of ammonium sulphate, 150 gm of superphosphate and 100 gm of muriate of potash per plant have recorded the maximum yield. Out of 16 different standards tried for pepper, *Erythrina indica* and *Grevillia robusta* proved to be better than other standards tried. Intensive research on the control of the 'Katte' disease of cardamom is now in progress.

CEREAL PRODUCTION KINDLES NEW HOPE IN HIMACHAL

- Valleys and lower areas of Himachal Pradesh soon to be converted into granaries.
- High-yielding varieties of wheat and hybrid and composite varieties of maize usher in an era of plenty.
- The gap between the production and requirements of foodgrains has been brought down to less than half from a lac and twenty thousand metric tonnes.

This leaves Himachal Pradesh well within the reach of achieving surplusage in foodgrains within the next few years.

- Multi-cropping experiments now being put into practice on a large scale and new dimension to agricultural production programme in the Pradesh.
- The Package Programme in Mandi Ditsrict has given insight and experience in ameliorating the lot of the farming community in the Pradesh.

Director of Agriculture
HIMACHAL PRADESH, SIMLA-5.

TRANSFORMING SORGHUMS

N. GANGA PRASADA RAO
Project Co-ordinator (Sorghum)
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RESEARCHES leading to the improvement of sorghum, the premier rainfed food and fodder crop of the country, have made more progress during the past decade than in the preceding period. These investigations embraced the fields of plant breeding and agronomy leading to the development of new hybrids and varieties and their production technology, entomology and pathology resulting in the development of insect and disease control measures besides attempts at nutritional upgrading of this poor man's cereal. Today an integrated approach to sorghum improvement is feasible; some of the more important findings of immediate applicational value are described.

Early Work

Natural selection and domestication over thousands of years has resulted in the development of numerous varieties highly local in their adaptation. Most of the present day improved varieties are the result of pure line selection practised in principal local varieties. Limited intervarietal hybridisation followed by selection has primarily contributed towards combining existing levels of grain yield with juicy stems to improve forage quality; noticeable changes in yield levels were not marked. Prominent among those who contributed to the genetics and breeding of sorghum in the early years were G.N. Rangaswamy Ayyangar and his colleagues from the then Madras State and Rao Saheb Kottur and his colleagues from the then Bombay State. A review of the earlier varietal improvement work by Chavan and Shendge (1957) reveals that in spite of the availability of over a hundred improved strains, the yield levels remained low representing marginal increases (10—15%) over the base populations. Notable among the varieties developed during this early period which are still under cultivation are the *Co* series in Tamilnadu; the Nandyal, Guntur and Anakapalle series of Andhra Pradesh; the PJ *kharif* and *rabi* selections, *Saoner*, *Ramkel*, *Aispuri*, the *Maldandi* and *Dagadi* (compact headed) selections of Maharashtra; the *Bilichigan*, *Fulgar white*, *Fulgar yellow*, *Kanvi*, *Nandyal*, *Hagari*, *Yanigar* varieties of the Mysore State; the *Budh perio*, *Sundhia* and *Chasatio* of Gujarat; the selections of Gwalior and Indore from Madhya Pradesh; the *RS* selections of Rajasthan and a few others. In addition, there are also special varieties for popping, parching and to suit special requirements. The age old association and the consequent local preferences for the taste of the respective local varieties are the dominant reasons for their continued cultivation in spite of their erratic behaviour and low yields.

An examination of the trends in sorghum production in India does not reveal any marked increases in yields, the per hectare averages ranging from 400—480 kg The cultivation of tall, long duration varieties over a vast proportion of the area the yields of which are most affected in years of drought, almost the total absence of the practice of fertilization and the tradition of growing sorghums only under low populations have been the major limiting factors in realising higher yields.

Recent Hybrids and Varieties

As a result of the efforts under an accelerated hybrid sorghum project initiated by the Indian Council of Agricultural Research during the year 1962, which became a comprehensive Co-ordinated Sorghum Improvement Project from the beginning of the Fourth Five Year Plan period (1969-70), four commercial hybrids, CSH-1 (1964), CSH-2 (1965), CSH-3 (1970), PSH-2 (1970) and an improved variety *Swarna* (1968) were released for general cultivation. The development and release of these new hybrids and varieties marked a genetic breakthrough in the otherwise stagnant yield levels. The hybrids yielded 60—100% more grain than the presently available improved varieties.

The new hybrids and varieties represent dwarf plant types as against the traditional tall forms which lodge on fertilisation. Their response to fertiliser and population inputs is much superior to the traditional talls. *Swarna* is erect leaved and stands even thicker populations than CSH-1. While the total fodder yield of the new varieties is less than the talls, the fodder being less fibrous, is more digestible.

The new hybrids were not only high yielding, but they were characterised by stability of performance. Severe drought conditions prevailed during the years 1965 and 1966. Yet, in no year the average yield levels of CSH-2 were less than 25 Qtls/ha in yield trials or national demonstrations. Besides being drought tolerant, they also escape midge which has of late become serious with the late varieties of Maharashtra and Mysore. The new varieties have a decided advantage for midge and various diseases but they are relatively more susceptible to shoot fly and stem borer.

Components of Production

The development of high-yielding hybrids and varieties will not by itself contribute to the realisation of higher yields unless varietal improvement and researches in production technology go hand in hand. It is only then the potential yields could be translated into realised yields. Through cooperative efforts with the related disciplines of agronomy, entomology and plant pathology vast experimental data with regard to dates of planting, fertiliser schedules, insect and disease control measures leading to the development of the package of practices for the various sorghum growing regions of the country have been obtained.

Recommended Production Practices

Based on countrywide agronomic experiments, the following recommendations are available.

Time of sowing: (a) Under rainfed conditions during kharif, plant sorghum at the onset of first monsoon showers or slightly ahead; (b) During rabi, advance planting of sorghum by one month over normal dates, mid August or mid September depending on the locality. This assures high yield and minimum incidence of shoot fly.

Fertilisation: (a) Under rainfed conditions, the optimum level of N is 80—100 kg. The level of P_2O_5 and K_2O shall depend upon soil test; (b) The optimum time of application of N under medium to heavy textured soils is full at planting; in case of light textured soils, split application half at planting + half at knee-high stage is advantageous.

Plant population: The optimum plant population for dwarf sorghum hybrids is near about 2,00,000 plants/ha in rows 45 cm apart. *Swarna* can tolerate even higher populations.

Weed control: Pre-emergence aplication of Atrazine or Propazine at 0.50 a.i./ha + one late weeding would be more economical, safe and sure practice for controlling the weeds in sorghum, ultimately resulting in high grain yield.

Insect Control

Comprehensive pest control schedules have been developed based on extensive studies all over the country. The following recommendations provide guidelines for control of various pests and diseases as and when they occur. *Shoot fly*: The shoot fly damage has generally been observed in late sown kharif in all the sorghum growing areas, normally sown crops in rabi areas and monsoon crop in Tamilnadu. Where two crops of sorghum are taken in a year, the damage is likely to be heavy in both the crops.

(a) In kharif season, if the crop is sown as early as possible, with the onset of the monsoon it may escape shoot fly infestation. Higher seed rate (11 kg/ha) and uprooting and destroying the damaged seedlings, 10 to 12 days after germination, may significantly reduce the subsequent shoot fly injury.

(b) Where shoot fly is a serious problem, use sorghum seed treated with 5 parts (a.i.) carbofuran per 100 parts of seed. If carbofuran is not available use 5% disulfoton at 3.0 gm/metre row or 10% phorate granules at 1.5 gm/metre row. If carbofuran treated seed or disulfoton and phorate are not available, some control may be obtained in early kharif season by spraying the crop with carbaryl (50% WP) 2 kg, or endrin (20% EC) 1 litre, or a mixture of endrin (20% EC) 375 cc and methyl demeton (25% EC) 250 cc, or lindane (20% EC) 2 litres or dimethoate (30% EC) 250 cc in 450 to 500 litres of water per hectare. The crop should be sprayed twice, the first spray after 3 to 5 days of emergence of seedlings and the second 5 to 7 days after the first spray. Addition of a wetting agent in the sprays may give better results.

Stem borer: Uprooting the stubbles and burning them will reduce the possibilities of infestation.

(a) Apply granules of 4% endosulfan, 4% carbaryl or 2% lindane, two to three times at 10 days intervals, starting 20 days after emergence of seedlings. The rate of application for the three treatments should be 8, 12 and 15 kg/ha. Two applications will be sufficient in the states of Maharashtra, Andhra Pradesh, Tamilnadu and Mysore where borer is not very serious. The applications may be given 25 and 35 days after germination.

(b) Alternatively, the crop may be treated with spray formulations of the above insecticides at the same dose of active ingredients in 500 to 600 litres of water per hectare. With carbaryl or wherever mite is a problem, add 2 kg of wettable sulphur. Both the granules and the sprays should be directed towards the leaf whorls.

Earhead Pests

Midge: Burning of panicle residues and chaff obtained after threshing will destroy diapausing larvae of the midge which may otherwise become a source of infestation next year. If necessary, this may be made obligatory in the areas where heavy midge infestation is observed.

Uniform date of sowing, and sowing of only one variety should be recommended for a block.

For chemical control of the midge, spray the earheads before flowering (at about 50% panicle emergence) with endosulfan (35% EC) 1 litre, carbaryl (50% WP) 3 kg, or lindane (20% EC) 1.25 litres in 500 to 600 litres of water, per hectare. Repeat the spray after 4 to 6 days. Two per cent endosulfan dust or 10% carbaryl dust may also be used for midge control at 20 kg/ha. A 10% BHC dust at 20 kg/ha has also been reported to be effective from Maharashtra and Andhra Pradesh; give two applications as in the case of sprays.

For earhead bug and caterpillars at the milky stage, treat the earheads with 10% carbaryl dust with sulphur (for mites) 18 :2, or 10% BHC dust at 20 kg/ha.

Note: 1. The quantity of spray liquid mentioned is for bucket type sprayers; if back-packed mist blower is to be used, the quantity of water required will be about one-third, the quantity of insecticides added per hectare should be the same.

2. Proper precautions should be taken in using the poisonous chemicals.

Disease Control

Diseases have generally been not as serious as insect pests. The following recommendations will be useful in case of disease incidence.

(1) Seeds should be treated with either 'Thiram' or 'Agrosan' just before sowing since it is known that the fungicide deteriorates to a great extent on storage after treatment of the seeds.

(2) Where leaf spots and sugary disease are a problem in seed production fields, they may be sprayed with Zineb four times starting 30 days after sowing, boot leaf stage, 50% flowering and full flowering period. This has been found to be very effective in reducing the important leaf spot diseases as well as sugary disease.

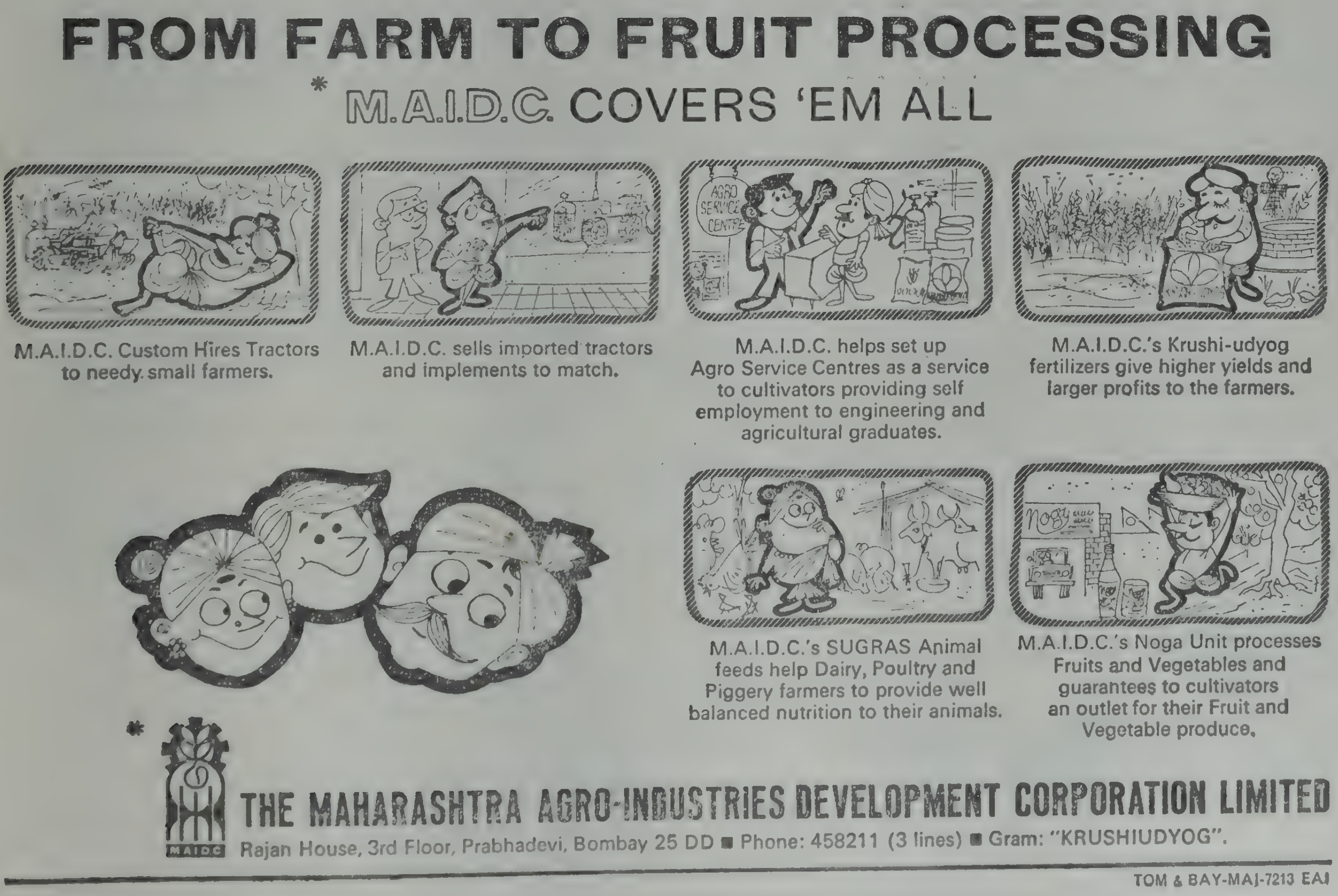
(3) To control mouldiness occuring as a result of rains received at grain maturing stage, spraying with a combination of aureofugin and captan may be restored to.

Outlook

Present studies aim at improvements in grain quality and tolerance to insect pests. New hybrids and varieties derived from exotic × Indian crosses combine these desirable attributes besides high yield and they are on the verge of release to the farmers. Two improved hybrids and two varieties are already at the pre-release stage. Attempts are in progress to combine B-carotene and higher lysine contents in future varieties.

Spread of available varieties with the recommended production practices on a scale commensurate with the magnitude of the crop could certainly make the much needed dent on the currently stagnating, national average yields of sorghum.

The work reported in this article is based on information available in various disciplines of the All India Co-ordinated Sorghum Improvement Project.



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YIELD RATES AND ASSOCIATED FERTILIZER AND MANAGEMENT PRACTICES

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Abstract. A study of the yield rates and extent of adoption of agronomic and management practices in different states showed that the average yield rate with the high-yielding varieties of both rice and wheat crops was fairly high (around 30 q/ha or more) in most of the states. On the use of fertilizer the doses of NPK applied were generally adequate. However, while the use of nitrogen on the high-yielding varieties was almost universal, that of phosphorus was limited to 60-80 per cent for rice and 50-70 for wheat. Potash was applied by very few farmers. The size of the holding did not show any influence on the yield rates or the fertilizer doses applied. However, high yield rates were generally accompanied by higher applications of nitrogen though this was not the case with P or K. As regards other improved practices like treated seed, cultural operations, plant protection and weed control measures, etc., their adoption was fairly marked on rice but somewhat limited in case of wheat crop.

ALTHOUGH the high-yielding varieties of cereals were introduced in the country in the early 60's, large scale cultivation of these varieties was taken up during 1966-67 onwards. The new varieties being highly fertilizer responsive, a phenomenal rise in the area under these varieties was observed in a short span of 2-3 years. This was particularly marked in areas where favourable soil and climatic conditions and irrigation facilities were available. Further, these varieties being of relatively shorter duration, intensive cropping could be practised in areas where one crop was grown in a year so far. Thus, what may be called a 'breakthrough' in the conventional Indian Agriculture was achieved with new seeds, improved practices and multiple cropping being adopted in large areas.

However, every rose has a thorn. The new varieties were not only found susceptible to pest and disease attack but also could not thrive well under adverse soil and climatic conditions. Thus, while under favourable conditions they offered highly promising results, under unfavourable conditions there was the risk of losing the crop altogether. Appropriate crop husbandry including proper soil and water management and pest and disease control measures thus assumed great importance. The yield rates of the new varieties would, therefore, be largely governed by the extent to which the farmer could adopt associated improved practices which, among others, required additional expenditure on labour and material inputs.

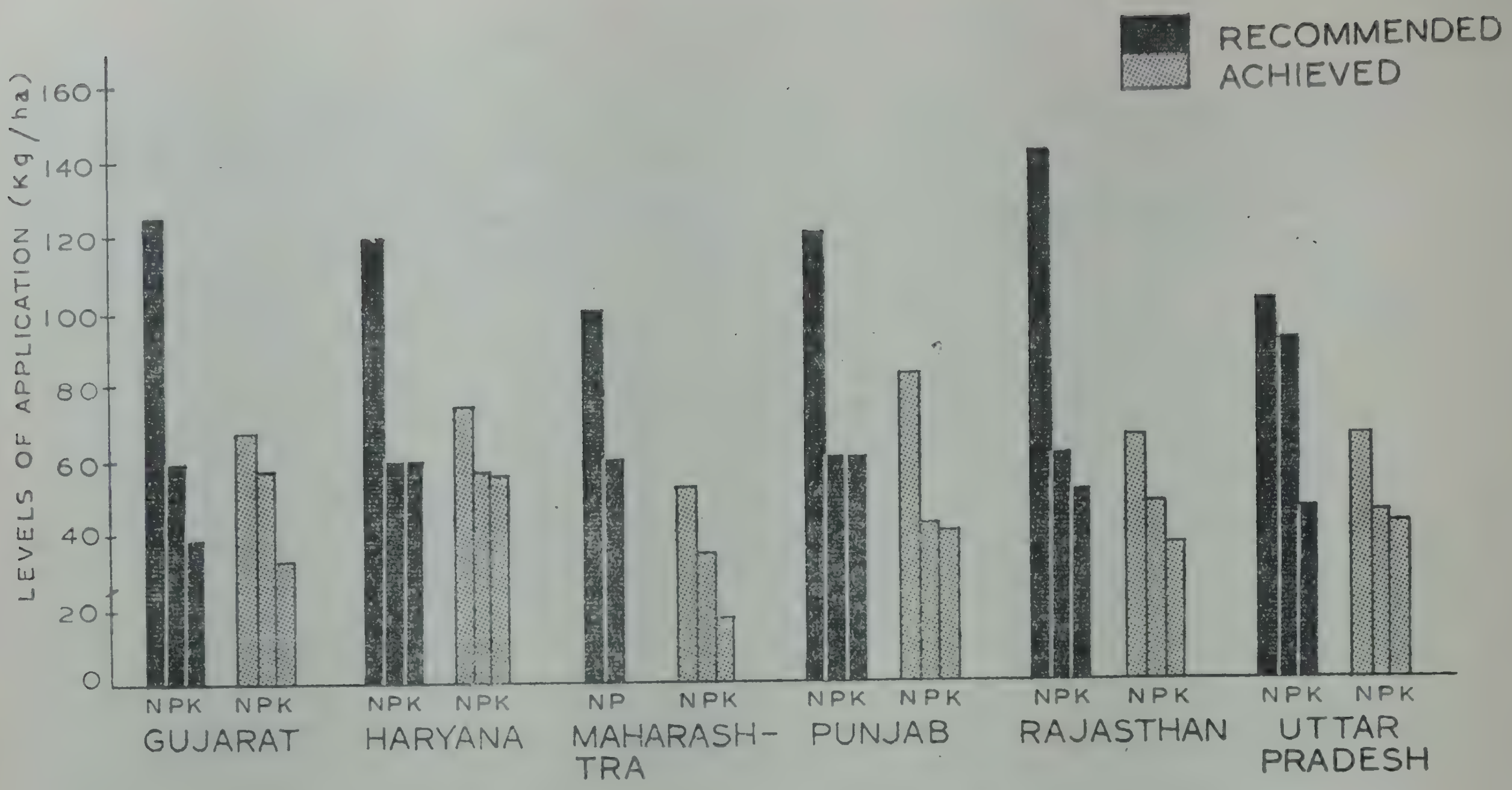
It was in this background that the IARS planned a large scale survey for Assessment of High-Yielding Varieties Programme with the main objectives of determining the spread and yield rates of high-yielding varieties of important cereals and the extent of adoption of agronomic and management practices under cultivators' conditions. The survey was initiated in 1969-70 in 88 districts covering 15 states in the country. The results pertaining to yield rates and associated practices adopted for rice and wheat crops in the various states during 1970-71 are given in this article.

Average Yield, Percentage of Fields Benefited by NPK and Rates of their Application

Rice (kharif)

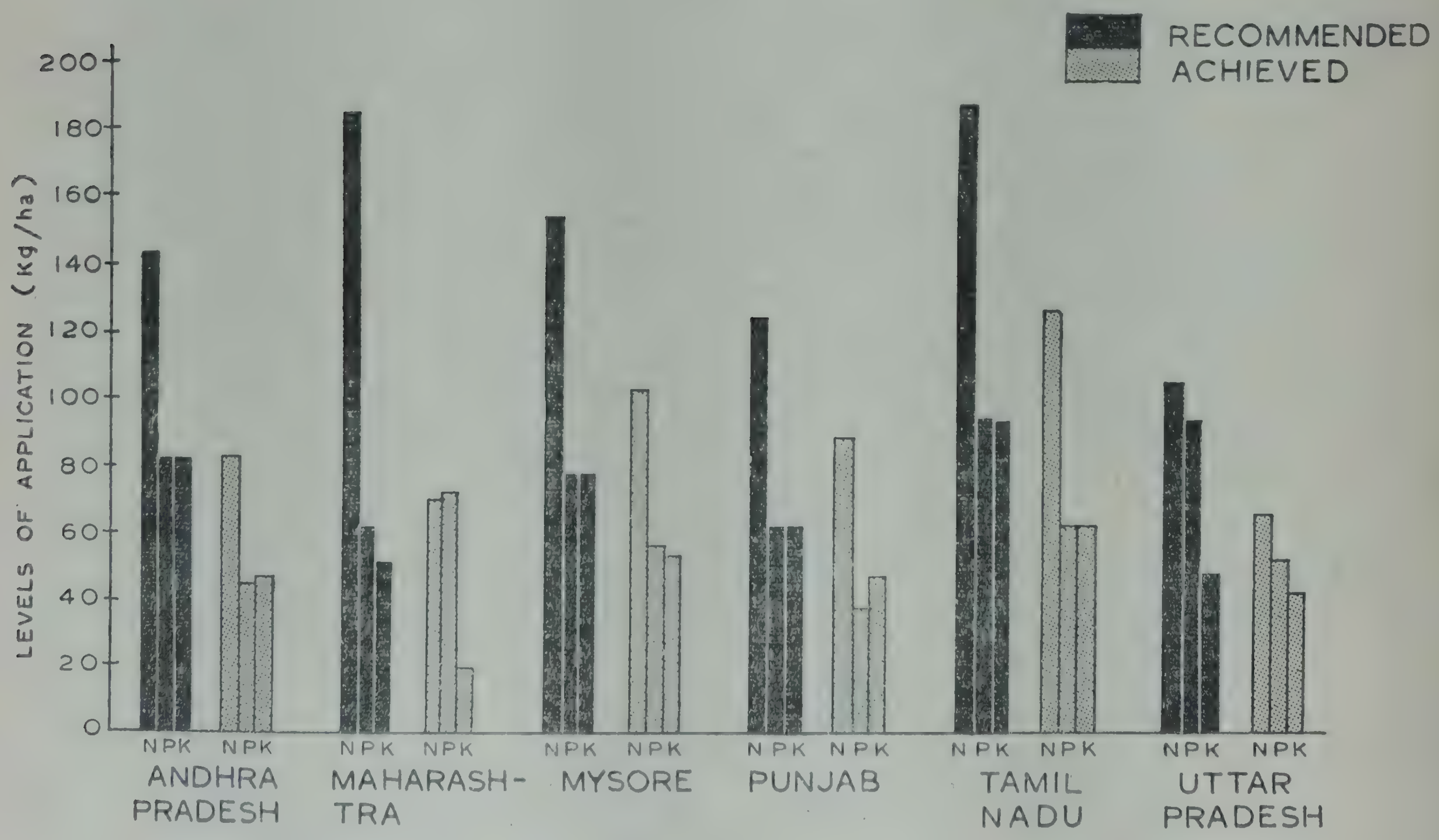
The results on kharif rice were available from 10 states and are presented in Table 1. The variety IR.8 was grown in all states. The yield rate of this variety was generally the highest and varied between 23 to 33 q/ha except in Mysore where the variety Manila gave an average yield of 37.2 q/ha. The yield rate of Jaya was quite comparable with IR.8 wherever the former was grown. Other high-yielding varieties which gave good yields were Hamsa, Mashori and ADT-27 in A.P., TN-1 in Assam, ADT-27 and IR.5 in Tamil Nadu and IR-49, Padma, TN-1, NSJ-200 and CH-4 in U.P. The average yields of the local varieties were substantially lower than those of the high-yielding varieties in all states, their range being 14 to 23 q /ha.

The number of cultivators using chemical fertilizers on high-yielding varieties was more than 90 per cent in the various states except Assam and Orissa. For local varieties,



SOURCE: FERTILIZER STATISTICS, F.A.I, 1970-71

Fig. 1. Fertilizer recommendations and achievements during 1970-71 in different States. Crop—wheat.



SOURCE: FERTILIZER STATISTICS, F.A.I, 1970-71

Fig. 2. Fertilizer recommendations and achievements during 1970-71 in different States. Crop—rice (kharif)

also, the percentage of farmers using fertilizers was fairly high and varied between 50 to 100 except in Assam where very few cultivators applied fertilizers to the local varieties.

Regarding the relative use of N P and K on kharif rice, use of nitrogen was fairly common, phosphorous was used by about 60 to 80 per cent of the cultivators while use of potassium was rather limited particularly in the northern states. As expected, the average yield rate of NPK application was higher for high-yielding varieties in all states. The average dose of nitrogen applied to high-yielding varieties was 80 kg/ha or more in a majority of states while for the local varieties it was generally below 60 kg/ha. The doses of P and K were also fairly high and generally more than 50 per cent of the level of nitrogen.

Rice (rabi)

The results for rabi rice were available from 4 states namely A.P. Mysore, Orissa and Tamil Nadu and are presented in Table 2. The variety IR.8 gave high yield rates varying between 25 to 40 q/ha in the various states. The variety Manila gave the highest yield of about 45 q/ha in Mysore. Good yields were also obtained with Jaya in Andhra Pradesh, Mysore and Orissa with ADT-27 in Andhra Pradesh, with TN-1 in Mysore and with IR-5 in Tamil Nadu. With the local varieties the yield was generally poor except in Mysore.

The percentage of cultivators using nitrogen on high-yielding varieties was more than 90 in the various states while P and K were used to a lesser extent. The average dose of nitrogen was fairly good in Mysore and Tamil Nadu and low in Andhra Pradesh and Orissa. The doses of P and K were, however, adequtae in relation to that of nitrogen.

With rabi rice, therefore, higher yields accompanied by adequate application of NPK were observed in Mysore and Tamil Nadu compared to Andhra Pradesh and Orissa. This is probably on account of better water supply conditions during rabi season pevailing in the former two states.

Wheat

The results for wheat were available from 8 states and are presented in Table 3. The variety Kalyan Sona (S-227) was grown in all states except Mysore. The average yield with this variety was of the order of 30 q/ha or more in Assam, Gujarat, Haryana, Punjab and Uttar Pradesh. The variety Sonalika (S-308) also gave high yields in all states where it was grown excpet in Maharashtra. Some of the other varieties that gave high yields in the various states were NP-824 in Gujarat, PV-18 in Punjab, Lal Bahadur in Rajasthan and NDM-1593 and UP-301 in U.P. The average yield with the local varieties was around 20 q/ha or lower in most of the States.

Nitrogen was applied to wheat crop by almost all cultivators in the various states except in Assam. Phosphorous was applied by about 50 to 70 of the cultivators while use of potash was rather limited. The average doses of N, P and K applied were fairly high in the various states except in Maharashtra.

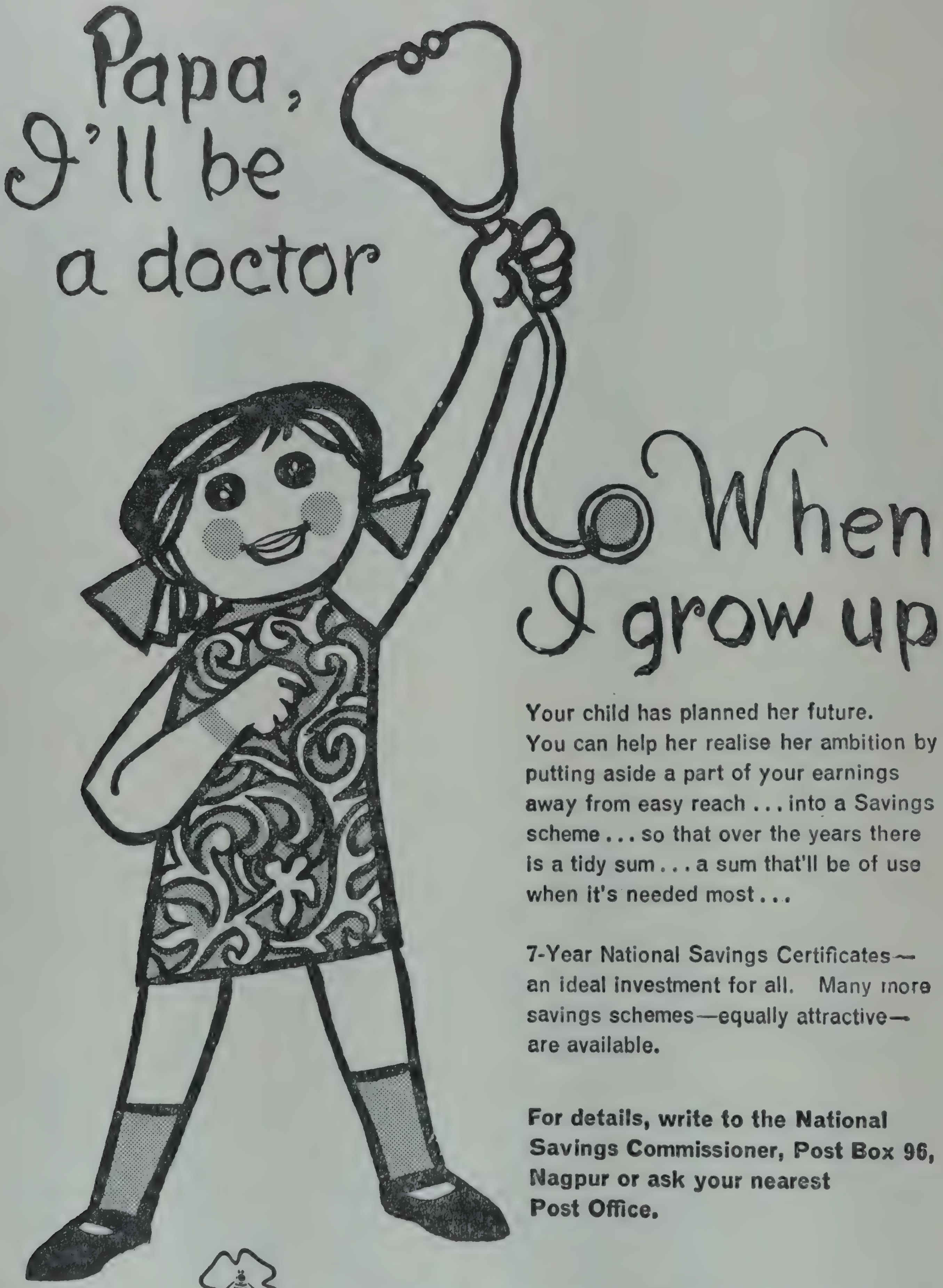
The substantial doses of N, P and K applied by cultivators to the HYV of both rice and wheat in the various states clearly shows that the cultivator is amply conscious of the need for adequate doses of fertilizer for obtaining good yields. That the percentage of cultivators using P and K was smaller than those using nitrogen (particularly for potash) reflects the limited availability of cash resources which he would like to utilize for ensuring adequate application of the primary nutrient viz., nitrogen. For P and K the cultivator would either not use them at all or (in case he could afford it) use them in adequate quantitites to meet the crop requirements of these nutrients.

Scope for Improvement in Rates of Fertilizer Application

The average doses of NPK applied to the high-yielding and local varieties of rice and wheat have been discussed above. Whether there was any scope for further improvement in these doses with a view to achieving higher production levels could be studied by a comparison of the doses applied with corresponding fertilizer recommendations in different states. For the high-yielding varieties of rice (Fig. 1), the rates of fertilizer application were generally between 50 to 70 per cent of the recommended doses in the major rice growing states. For wheat (Fig. 2), the levels of fertilizer given to high-yielding varieties were around 60 to 70 per cent of the recommended doses in Punjab and U.P. In Gujarat, Haryana and Rajasthan the levels of P and K were very close to the recommended levels while that of nitrogen was only around 50 per cent. For the local varieties of both rice and wheat the doses applied were almost the same as (sometimes even exceeded) the recommended levels. There, thus, appears to be considerable scope for obtaining higher yields by way of increased fertilizer application with high-yielding varieties of rice and wheat as per the state fertilizer recommendations.

Average yield of high-yielding varieties and doses of NPK applied for different holding size groups.

As is well-known the bulk of cultivators in India are small holders with limited cash resources. It may, therefore, be reasonably expected that the high-yielding varieties would be taken up more by large cultivators since it would involve higher expenditure on fertilizer and other improved practices. Similarly, the doses of NPK applied to the high-yielding varieties by cultivators with



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large holding size would be higher than those applied by cultivators with limited land, this aspect was studied by grouping the average yield and corresponding NPK doses for different holding size groups.

The number of cultivators adopting high-yielding varieties of rice in the small holding size groups (less than 2 hectares) was around 50% or more except in Haryana and Punjab. For wheat, similaly, this percentage was small only in Punjab, Haryana and Maharashtra. The spread of the high-yielding varieties is therefore, not limited to only large holdings. The low participation of cultivators with holdings smaller than 2 hectares in Punjab and Haryana is probably because the number of cultivators in this category is not large in these two states.

Regarding the variation in the yield rates as also in the levels of NPK applied in different holding size groups, no trend was obserrved in any state for any crop. The variation in the yield rates as well as in the doses of fertilizers applied is, therefore, governed by factors other than the size of the holding.

Levels of NPK application for different yield rates

Apart from the variation in the average yields and fertilizer rates between the states, considerable variation was observed in the yield rates and doses of NPK applied from field to field within a state. It would, therefore, be of interest to investigate whether variation in the yield rates in a state would be explained by varying doses of NPK applied. This was studied with the help of frequency distribution of NPK doses corresponding to yield rates grouped with an interval of 5 q/ha.

The doses of nitrogen applied generally showed an increasing trend with higher yield rates for both rice and wheat crops. In the case of phosphorous a slight trend was noticeable for wheat crop in some of the states. No trend could be observed for potash mainly because its use was very much limited.

It therefore appears that high yields were accompanied by high doses of nitrogen while for phosphorous and potash this was not so. This is possibly because the farmers have become aware that they could optimise their limited cash resources by a judicious use of fertilizers particularly P and K which apparently need be applied only to the soils deficient in these nutrients. Appropriate levels of P and K for any field and crop could be ascertained by soil testing so that high yield rates would no longer be associated with high doses of P and K.

The extent of adoption of improved practices:

In the context of the fairly high levels of yield rates and associated fertilizer application, another aspect of interest would be the extent to which the cultivators adopted the various improved practices recommended in different states. This was investigated for rice (kharif) and wheat crops with the help of percentage frequency of cultivators adopting different improved practices. The results are presented in Table 4.

Rice (kharif)

Irrigation was given to kharif rice by most of the cultivators in the various states except in Assam Maharashtra and Orissa. Assam has good rainfall while in the other two states irrigation facilities in kharif season are rather limited. Treated seed was used by a majority of cultivators in the various states except in Assam, Orissa, Haryana and Punjab. Cultural operations were done by a substantial number of farmers only in Mysore state, while improved implements were used by a majority of cultivators in Mysore, Punjab and Tamil Nadu. Plant protection measures were adopted by the bulk of cultivators in the various states except in the northern states of Punjab, Haryana and U.P.. Weed control measures (including hand weeding) were adopted by a good number of farmers in all states except Rajasthan, Maharashtra and Orissa. Adoption of rat control measures who reported to some extent in Andhra Pradesh, Haryana, Punjab and Rajasthan.

Wheat

Wheat was grown under irrigated conditions in all states except Assam where it was mainly rain fed. Treated seed was used by a majority of cultivators only in Maharashtra, Rajasthan and U.P. Improved implements were used mainly in Punjab, Rajasthan and Mysore, while other improved practices like plant protection measures, weed control, rat control, etc. were not used by cultivators to any substantial degree in the various states.

The study of extent of adoption of improved practices thus brings out some interesting findings:

(i) Improved practices like treated seeds, cultural operations, and plant protection, weed control and rat control measures were adopted more with rice than wheat crop. The use of improved implements was also more common on rice crop.

(ii) In some states a majority of cultivators did not adopt most of the recommended practices particularly in case of wheat crop. This may be due, at least in part, to the lack of complete awareness of the usefulness and importance of appropriate management practices for obtaining higher yields.

Intensive efforts for educating the farmers regarding appropriate crop husbandry practices therefore need to be taken up for increased agricultural production in the country.

TABLE 1. YIELD RATES, EXTENT OF ADOPTION AND AVERAGE RATES OF APPLICATION OF CHEMICAL FERTILIZERS DURING 1970-71.

Season : Kharif Crop : Rice

State	*No. of districts*	*Variety*	*Av. yield* (Q/ha)	S.E. (%)	*Percentage of fields benefited*			*Average rates of application* (kg/ha)		
					N	*P*	*K*	*N*	*P*	*K*
1	2	3	4	5	6	7	8	9	10	11
Andhra Pradesh	9	IR. 8	26.7 (253)@	2.6	96	65	17	86	45	45
		Jaya	27.5 (114)	5.1	97	76	13	100	51	53
		Masehri	23.7 (107)	2.5	100	86	17	67	40	47
		CO-29	19.1 (97)	3.8	95	49	9	52	35	33
		Hamsa	24.1 (57)	5.5	98	75	4	87	43	*
		ADT-27	22.8 (32)	6.2	91	34	9	71	48	*
		Overall HYV	24.8 (681)	1.7	97	68	14	80	44	46
		Local	18.6 (644)	1.5	86	46	4	54	35	36
Assam	2	IR. 8	32.8 (110)	3.5	73	71	65	56	29	34
		TN-1	27.8 (10)	9.0	70	70	70	40	19	19
		Overall HYV	32.3 (121)	3.3	73	71	66	54	29	33
		Local	17.8 (111)	3.9	4	4	4			*
Haryana	1	IR. 3	28.3 (52)	4.8	100	57	13	90	50	72
		Local	16.9 (51)	4.5	96	24	4	56	43	*
Maharashtra	1	IR. 8	25.3 (28)	6.3	100	93	46	68	71	18
		Local	16.5 (31)	8.6	77	71	42	53	51	14
Mysore	3	IR. 8	33.3 (163)	2.9	94	86	67	100	53	53
		Jaya	33.5 (31)	5.3	100	81	90	88	55	57
		Manila	37.2 (31)	4.6	100	97	74	122	59	41
		Overall HYV	33.6 (238)	2.3	96	87	71	101	55	52
		Local	23.2 (237)	2.2	87	68	49	67	37	35
Orissa	3	IR. 8	22.9 (71)	7.1	77	44	24	89	32	61
		TN-1	10.6 (20)	27.0	75	60	20	61	39	*
		Padma	16.3 (15)	19.0	73	40	27	62	52	*
		Overall HYV	19.3 (120)	6.6	79	50	24	78	36	55
		Local	14.4 (117)	5.5	54	17	3	47	18	*
Punjab	4	IR. 8	30.7 (253)	1.8	98	41	7	86	35	45
		Local	19.5 (243)	2.8	90	16	2	59	37	66
Rajasthan	1	IR, 8	24.1 (45)	6.2	100	84	24	122	47	37
		Overall HYV	24.3 (52)	5.9	100	83	27	120	48	37
		Local	17.9 (32)	7.3	100	81	6	78	41	*
Tamil Nadu	4	IR. 8	32.1 (187)	2.6	100	88	82	130	74	76
		IR. 5	23.1 (37)	6.6	100	86	81	124	70	66
		ADT-27	25.3 (14)	7.2	100	71	57	81	67	44
		CO-29	24.0 (12)	10.0	100	58	25	79	29	*
		Overall HYV	29.9 (284)	2.3	100	86	79	121	70	69
		Local	19.5 (252)	2.5	95	63	53	63	35	33
Uttar Pradesh	15	IR. 8	22.9 (425)	2.4	96	56	47	67	49	42
		TN-1	19.7 (149)	4.2	91	54	48	65	48	39
		Padma	19.9 (103)	4.5	92	65	52	70	52	42
		IR. 49	21.5 (82)	4.2	95	66	52	62	56	42
		NSJ-200	18.4 (82)	4.2	95	39	28	51	39	34
		Jaya	22.4 (66)	6.5	94	83	73	78	53	44
		CH-4	17.8 (42)	9.3	83	36	21	49	43	38
		T-21	15.7 (41)	7.8	71	22	7	37	39	*
		Overall HYV	21.0 (1014)	1.6	93	56	45	64	49	41
		Local	13.8 (939)	1.5	79	23	17	34	27	23

@ Figures in brackets indicate the number of observations on which the results are based.

* Results not presented as based on very few observations.

TABLE 2. YIELD RATES, EXTENT OF ADOPTION AND AVERAGE RATES OF APPLICATION OF CHEMICAL FERTILIZERS DURING 1970-71

Season : Rabi Crop : Rice

State	*No. of district*	*Variety*	*Av. yield* (q/ha)	SE (%)	*Percentage of fields benefited*			*Average rates of application* (kg/ha)		
					N	*P*	*K*	*N*	*P*	*K*
1	2	3	4	5	6	7	8	9	10	11
Andhra Pradesh	3	CO-29	17.9 (23)@	8.1	96	74	30	49	26	25
		IR. 8	33.7 (19)	6.5	100	26	11	70	33	*
		Overall HYV	25.7 (54)	5.8	98	54	22	61	29	25
		Local	16.2 (26)	6.3	85	50	8	39	27	*
Mysore	3	IR. 8	39.4 (116)	3.5	96	85	65	89	48	56
		Manila	44.9 (58)	5.1	95	84	57	106	54	53
		Jaya	38.4 (32)	5.9	94	84	75	83	38	45
		TN-1	36.6 (15)	4.4	100	87	67	104	52	45
		Overall HYV	40.5 (222)	2.5	95	85	64	94	48	53
		Local	25.7 (163)	3.2	88	68	41	64	35	35
Orissa	3	IR. 8	25.7 (33)	7.2	94	82	21	91	42	64
		Jaya	31.5 (24)	10.5	92	83	29	84	47	67
		TN-1	19.8 (21)	15.6	90	76	19	57	40	*
		Padma	18.1 (14)	19.4	93	64	14	54	37	*
		Overall HYV	24.6 (94)	5.9	91	78	22	77	42	62
		Local	12.7 (54)	7.1	67	50	2	32	20	*
Tamil Nadu	4	IR. 8	31.0 (184)	2.8	99	92	82	136	72	77
		CO-29	22.4 (23)	7.9	100	87	83	80	32	34
		IR. 5	29.8 (17)	8.2	100	100	88	102	58	57
		ADT-27	17.2 (16)	8.2	100	69	75	61	33	32
		Overall HYV	28.8 (270)	2.4	100	90	83	122	65	68
		Local	18.1 (201)	2.4	97	59	48	58	38	33

@ Figures in brackets indicate the number of observations on which the estimates are based.
* Results not presented as based on very few observations.

TABLE 3. YIELD RATES, EXTENT OF ADOPTION AND AVERAGE RATES OF APPLICATION OF CHEMICAL FERTILIZERS DURING 1970-71

Season : Rabi Crop : Wheat

State	*No. of districts*	*Variety*	*Av. yield* (q/ha)	SE (%)	*Percentage of fields benefited*			*Average rates of application* (kg/ha)		
					N	*P*	*K*	*N*	*P*	*K*
1	2	3	4	5	6	7	8	9	10	11
Assam	2	Sonalika	32.9 (108)@	4.5	56	55	52	74	46	35
		Kalyan Sona	38.1 (15)	8.2	53	47	46	70	56	89
		Overall HYV	33.3 (125)	4.0	57	54	52	73	47	40
		Local	22.6 (30)	7.2	3	3	3	*	*	*
Gujarat	3	Kalyan Sona	31.2 (146)	3.5	92	36	7	64	60	31
		Sona lika	36.2 (62)	5.1	100	53	8	75	57	50
		NP-824	37.6 (18)	10.2	100	100	22	68	53	*
		Overall HYV	33.1 (230)	2.8	95	46	7	68	58	33
		Local	25.2 (230)	2.8	93	33	*4	52	50	11
Haryana	3	Kalyan Sona	29.6 (155)	2.7	99	30	6	76	57	59
		Sona lika	28.9 (48)	6.5	83	27	4	67	60	*
		Overall HYV	29.5 (209)	2.6	95	30	5	74	57	56
		Local	20.4 (200)	2.4	70	12	2	52	44	*

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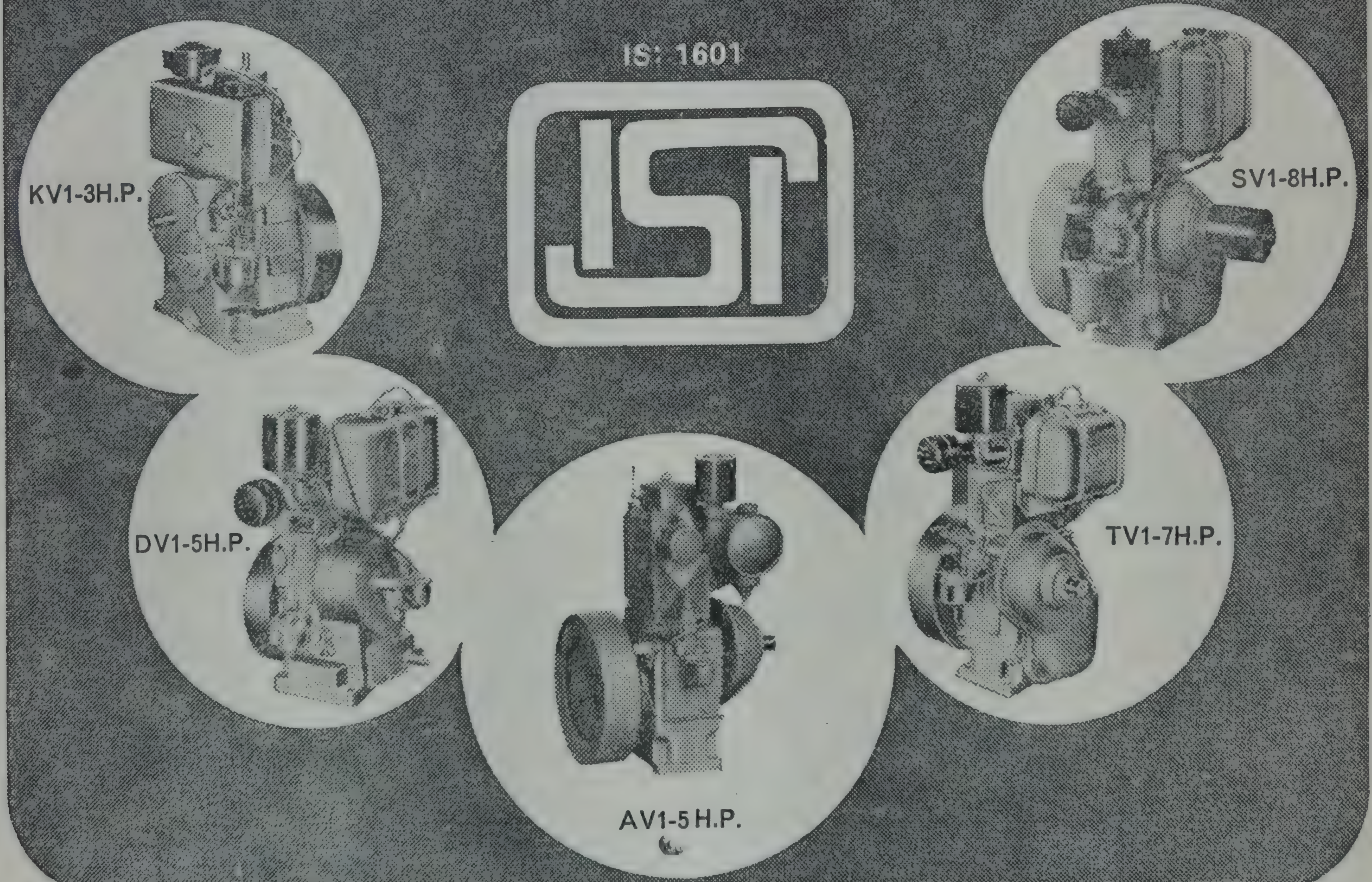

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2	2	3	4	5	6	7	8	9	10	11
Maharashtra	15	Kalyan Sona	18.0 (426)	2.3	89	62	28	54	34	15
		NI. 747-19	16.0 (221)	4.3	74	44	25	50	36	20
		NI-917	15.5 (182)	3.2	82	55	36	52	34	17
		Sona lika	18.9 (94)	4.7	87	50	22	53	31	20
		Sarbati Sona	17.4 (35)	8.1	80	49	14	56	66	13
		Sonara-64	18.5 (12)	13.3	92	42	—	49	25	—
		Overall HYV	17.1 (973)	1.6	84	55	27	52	35	17
		Local	11.1 (955)	1.8	41	22	11	43	30	17
Mysore	1	Chhoti Larma	24.1 (23)	9.0	87	43	26	69	43	40
		Saphed Larma	26.9 (22)	8.8	95	77	41	77	60	47
		Larma Rojo	21.9 (14)	16.2	93	50	7	73	59	*
		Overall HYV	24.1 (80)	4.9	89	59	31	70	50	42
		Local	12.3 (79)	6.6	59	40	28	54	31	24
Punjab	6	PV-18	36.2 (17)	9.4	100	59	6	77	37	*
		Kalyan Sona	30.3 (399)	2.4	98	55	15	82	42	40
		Overall HYV	30.5 (429)	2.3	98	55	15	82	42	40
		Local	18.6 (207)	2.0	84	16	3	47	25	17
Rajasthan	3	Sonalika	28.0 (84)	4.3	81	55	24	74	52	42
		Lal Bahadur	30.1 (83)	5.3	90	54	31	62	44	32
		Kalyan Sona	25.6 (36)	7.6	86	47	14	47	40	37
		Overall HYV	28.6 (211)	3.0	86	55	27	64	47	35
		Local	19.6 (123)	4.1	46	16	5	37	37	30
Uttar Pradesh	15	Sonalika	32.9 (644)	1.3	94	69	58	63	44	41
		Kalyan Sona	32.4 (169)	2.6	95	75	66	67	44	40
		K-68	23.4 (85)	3.9	89	64	54	47	32	27
		NDM-1593	42.6 (61)	3.3	97	87	82	74	52	42
		Sharbati Sonora	33.1 (31)	6.7	94	77	74	64	47	42
		U.P-301	38.4 (27)	7.5	93	81	78	82	52	42
		Overall HYV	32.7 (1063)	1.1	94	71	62	64	44	40
		Local	20.1 (647)	1.5	76	37	29	35	25	22

@ Figures in brackets indicate the number of observations on which the estimates are based.

* Results not presented as based on very few observations.

TABLE 4. FREQUENCY OF CULTIVATORS (%) ADOPTING THE RECOMMENDED IMPROVED PRACTICES DURING 1970-71

State	*Total No. of fields sampled*	*Percentage of cultivators adopting*						
		Treated seeds	*Irrigation*	*Cultural operations*	*Improved implements*	*Plant protection*	*Weed control*	*Rat control*
Rice (Kharif)								
Andhra Pradesh	681	60	98	9	28	80	34	24
Assam	111	38	22	21	31	60	64	2
Haryana	52	40	90	0	36	14	46	19
Maharashtra	31	55	58	36	6	68	16	0
Mysore	238	64	96	64	92	81	93	9
Orissa	117	21	55	8	17	61	24	3
Punjab	256	32	100	5	54	18	52	39
Rajasthan	52	54	100	17	10	64	17	2
Tamil Nadu	284	75	99	31	69	95	43	25
U.P.	1014	56	74	4	20	31	46	3
Wheat								
Assam	125	28	18	19	15	22	22	13
Haryana	209	11	98	5	23	1	13	28
Gujarat	230	38	100	12	27	9	18	8
Mahrashtra	973	66	95	4	6	10	14	42
Mysore	80	32	99	4	50	12*	26	18
Punjab	429	25	100	6	52	N.A.	N.A.	N.A.
Rajasthan	211	79	97	10	58	N.A.	N.A.	N.A.
U.P.	1063	68	97	4	25	N.A.	N.A.	N.A.

* N.A. stands for not available.

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TABLE 5. EXTENT AND INTENSITY OF CROP DAMAGE IN FIELDS SOWN WITH HIGH YIELDING VARIETIES DUE TO DIFFERENT CAUSES DURING 1970-71

State	*Total No. of fields sampled*	*Fields not affected* (%)	*Fields with yield rate below* 10 q/ha (%)	*Percentage of fields deamaged due to*																	
				Excess water		*Drought*		*Disease*		*Insect posts*		*Cattle*		*Rats*		*Weeds*		*Other*		*Overall*	
				M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H
Rice (Kharif)																					
Andhra Pradesh	681	70	7	4	2	1	*	8	5	9	4	1	*	3	1	*	0	1	1	18	12
Assam	111	59	4	4	6	14	7	1	0	5	1	6	3	2	1	2	0	6	12	17	24
Haryana	52	93	6	0	0	4	2	0	0	0	0	0	0	0	0	0	0	2	0	5	2
Maharashtra	31	84	3	0	0	3	0	3	0	10	0	0	0	0	0	0	0	0	0	16	0
Mysore	238	86	3	2	*	1	2	4	1	2	*	1	0	*	0	1	0	1	0	10	4
Orissa	117	48	36	9	5	3	3	3	0	10	24	0	1	0	0	1	1	1	0	21	31
Punjab	256	96	0	2	*	*	0	1	0	*	0	0	0	0	0	0	0	0	0	4	*
Rajasthan	52	83	6	2	0	2	0	4	8	0	2	0	0	0	2	0	0	0	4	6	11
Tamil Nadu	284	90	3	*	0	1	1	1	1	2	2	*	0	2	1	0	0	0	1	6	4
U.P.	1014	75	6	4	3	10	4	1	*	3	*	*	*	*	0	1	*	1	*	15	10
Wheat																					
Assam	125	75	3	0	0	8	14	0	0	0	0	1	1	0	0	0	0	0	1	9	16
Haryana	209	94	3	0	0	4	1	0	0	1	0	0	0	0	0	0	0	1	0	5	1
Gujarat	230	85	1	0	0	0	0	0	0	*	0	0	0	7	2	2	0	*	*	11	4
Maharashtra	973	91	20	1	0	*	0	*	0	1	0	*	*	5	*	1	0	2	*	8	1
Mysore	80	97	8	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	0
Punjab	429	97	1	*	0	1	*	0	0	0	0	0	0	*	0	1	0	*	0	3	*
Rajasthan	211	82	4	1	0	4	*	1	0	1	0	1	1	1	0	2	0	3	2	14	4
U.P.	1063	92	2	1	1	2	*	*	*	*	*	*	*	2	*	1	*	1	1	7	1

* Less than 1 per cent

Extent and Intensity of Crop Damage

The frequency distribution of fields according to yield rates showed that in a number of fields yield was extremely poor (less than 10 q/ha) even with adequate application of NPK. Apart from other factors like poor soil fertility and drainage, etc. adverse climatic factors, pest and disease attack and damage due to cattle, rats, weeds, etc. would also contribute to a large extent in bringing down the yields. The extent of damage due to various causes was studied for kharif rice and wheat crops. An intensity of damage between 5 to 25 per cent was denoted as 'moderate' (M), while damage of more than 25 per cent was denoted as 'high (H). The results are presented in Table 5.

As many as 52 and 41 per cent of the fields reported moderate to heavy damage in Orissa and Assam states respectively. In Orissa the main cause was pest attack followed by excess water due to havy rains and flood. In Assam the main factor contributing to the crop damage was drought (21%) followed by excess water 10(%). Other states reporting substantial damage were Andhra Pradesh (30%) and U.P. (25%), the main cause being pest and disease attack in the former and drought/excess water in the latter. It may be added that of all the states the crop damage was the highest in Orissa where 36% of fieds gave a yield of less than 10 q/ha.

Moderate to heavy damage in 25% of the fields was reported in Assam, the main cause being drought. However, the proportion of fields giving a yield rate of 10 q/ha or less was the highest in Maharashtra (20%) where the intensity of crop damage reported was less than 10%.

The above study of damage due to various causes clearly brings out the important role of appropriate agronomic and management practices. Adoption of such practices would greatly contribute to bringing down the crop damage and thus lead to realization of higher yields.

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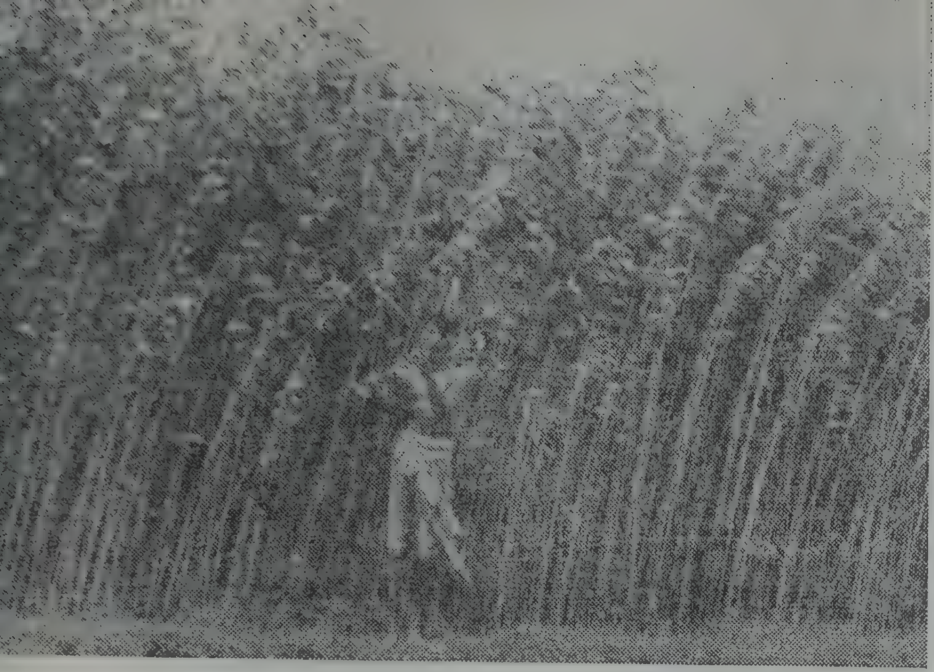


Fig. 1. The new tossa JRO 878

QUARTER CENTURY OF RESEARCH IN JUTE AND ALLIED FIBRES

T. GHOSH
Jute Agricultural Research Institute
Barrackpore, W. Bengal

THE Indian Jute Mills, mostly concentrated in West Bengal, continue to produce goods worth Rs 4100 millions, earn foreign exchange amounting to Rs 2300 millions, employ 0.4 millions in the industry and trade and 2.0 millions of Indian farmers are partially dependent on the earnings from the crop. The importance of jute cannot be overemphasised even today despite the oft' quoted threat from synthetics.

After the partition, India had to rush for extending area under jute without having consideration for efficient and inefficient areas; by the end of second plan period it was realised that extension of area under jute beyond 81,3000 hectares (roughly 2 million acres) was not much possible; hence research was directed with an all-out emphasis on increase in yield per unit area, the national average yield per hectare being a poor 12.4 quintals only.

Towards this endeavour the Jute Agricultural Research Institute which was newly established in 1948 contributed much in the last 25 years; new improved varieties were selected, tested and released. The cultural practices including use of fertilizers, were worked out and recommended. Quality of fibre being one of the most important features, detailed studies have been made towards elucidation of the process of retting and recommendation made on the basis of informations thus gathered.

Below is given a short account of the improved varieties of jute and mesta, the fibre of the latter being spinnable on jute machinery. The release of JRO 878 and JRO 7835 mark a new era in jute breeding initiated by the location of new characters like 'resistance to premature flowering' and 'non-shattering pod' in "Sudan Green"—a semiwild form by B. Dasgupta.

Varieties of Jute

The Improved Tossa Varieties

a. JRO 632 (1939-1954): Suitable for sowing from middle of April to first week of May. Yield potential is around 37 quintals/ha under optimum condition. Average reached under National Demonstration (1967-70) is 27 quintals per hectare. This variety has completely replaced the old standard tossa variety Chinsurah Green (or C.G.) which was the favourite from 1919 to 1954.

b. JRO 878 (1961-1967). Suitable for sowing from second week of March till end of the month on mid and high lands of southern districts of West Bengal. This variety is unique in being resistant to premature flowering, has non-shattering pod and in being largely non-lodging. Average yield is 27 quintals per hectare the optimum being 32 quintals. It is suitable for double cropping with paddy under irrigated condition.

Since JRO 878 is showing susceptibility to root-rot in high rainfall areas, release of more resistant types having the advantages of JRO 878 is being considered; the varieties are JRO 524 and JRO 808.

C. JRO 7835 (1961-71); It has all the advantages of JRO 878 but can be sown till middle of May and even beyond. It is a non-lodging variety with average yield of 28 quintals/ha.

d. JRO 3690 (1964–71). A hybrid obtained from crossing mutants induced by X-ray. The yield is 12 per cent higher than JRO 632 which it aims to replace. Will suit areas where sowing is done around middle of April. The variety is being tested under Co-ordinated Project and may be released soon.

This variety is the first successful contribution in mutation breeding by D.P. Singh and is the result of ceaseless search initiated around 1956 with gamma and X-ray induction of mutation in jute, by Subir Sen and team.

The Improved White Jute Varieties

(i) JRC 321 (1942–54): Suitable for early sowing in late February to mid-March in low-lying areas of Assam, N. Bengal, Purnea, Terai of U.P. This has now replaced the old standard variety D 154 in low-lying areas. The yield could be anywhere between 20 and 30 quintals

(ii) JRC 212 (1941–1952): Suitaable for sowing from middle of March to first week of April in mid and high lands of Assam, N. Bengal, N. Bihar, U.P. and mid-lands of Orissa and South Bengal. Average yield 24 quintals per hectare the maximum being 37 quintals per hectare.

(iii) JRC 7447 (1962–1970): An X-ray derivative of JRC 212; with nitrogen at 60 to 80 kg/ha it yields about 1.5 to 3 quintals more per hectare than JRC 212. Suitable for all white jute areas except in low lands.

(iv) JRC 1108 (1954–1968): A variety having best resistance to stem rot with yield equal or slightly below JRC 212. The variety is being tested in different states under the Co-ordinated Project, Jute and Allied Fibres.

(v) JRC 6382 (1962–70): The variety yields 12 per cent more than JRC 212 and is also under test with different jute growing States.

Improved Varieties of Mesta

It was shown that mesta particularly *H. cannabinus* could be grown in less humid areas adjacent or near the jute belt. Hence attempts were made to formulate the agronomic practices for cultivation of mesta and find a supplementary source of fibre for the jute mills. At the time of partition of India there was no known standard variety for either of the two mestas viz. *Hibiscus sabdariffa* and *H. cannabinus*. The Institute selected and developed RT 2 of the former species which again has now been replaced by HS 4288, which yields 23 quintals with normal input and maximum so far obtained is 30 quintals per hectore. At Adamalavalasa AMV 1—another improved variety has been developed and released.

Fig 2. A. Hibiscus sabdariffa var. altissima : HS 4288

Similarly, the Institute has developed HC 583 the improved *Hibiscus cannabinus* (also known as Kenaf which yields 20 quintals to 26 quintals per hectare in 150 days.

The jute varieties and HC 583 described above take 135 to 150 days to give the maximum yield indicated. HC 4288 takes 160 to 180 days to yield 23 to 30 quintals. All these varieties require good nurture and fertilizers.

Information gained during the last 25 years about improved technique of cultivation that go with high yield of fibre have been extended as National Demonstration Scheme and by now much of the recomendadations are known to the cultivators.

Improving The National Average Yield

It has been amply demonstrated that in new alluvial soils, an *olitorius* improved variety can yield 36 to 37 quintals per hectare with N_{40} P_{20} K_{40} with a spacing of 20 cm x 5-7 cm. Important cultural operations include liberal application of F. Y. M., two manual weeding and mulching of soil thrice with a wheel hoe.

Similarly, with a white improved variety (JRC 212) and yield of 38.5 q/ha was obtained with N_{80} P_{40} K_{80} and the spacing of 30 cm x 5-7 cm, other inputs being same as in *olitorius* variety. It has further been found that in lateritic soil the nitrogen application must be above 60 kg/ha the optimum being anywhere between 60 and 80, both for tossa or white varieties.

The technique of foliar feeding of nitrogen has been tested on both *capsularis* and *olitorius* varieties. It has been found that areas where a spell of drought intervenes between seedling stage and break of monsoon, growth in jute can be accelarated by application of urea in water and it has proved advantageous. The details have been elaborated under 'package of practices' elsewhere.

The National Average today is around 12.4 q/ha. Even if loss of crop due to natural calamities is taken into account there is no reason why the National Average Yield could not be improved to 20 quintals per hectare. Emphasis is to be laid on (i) saturation by seed of improved variety, (ii) timely control of weeds, (iii) application of requisite quantity of fertilizer with use of correctives where necessary.

Since a very general recommendation has its own limitations, the jute belt with its varied soil type and climate has been divided into nine broad zones, so that recommendations could be more precise and effective towards overall increase in production and improvement of

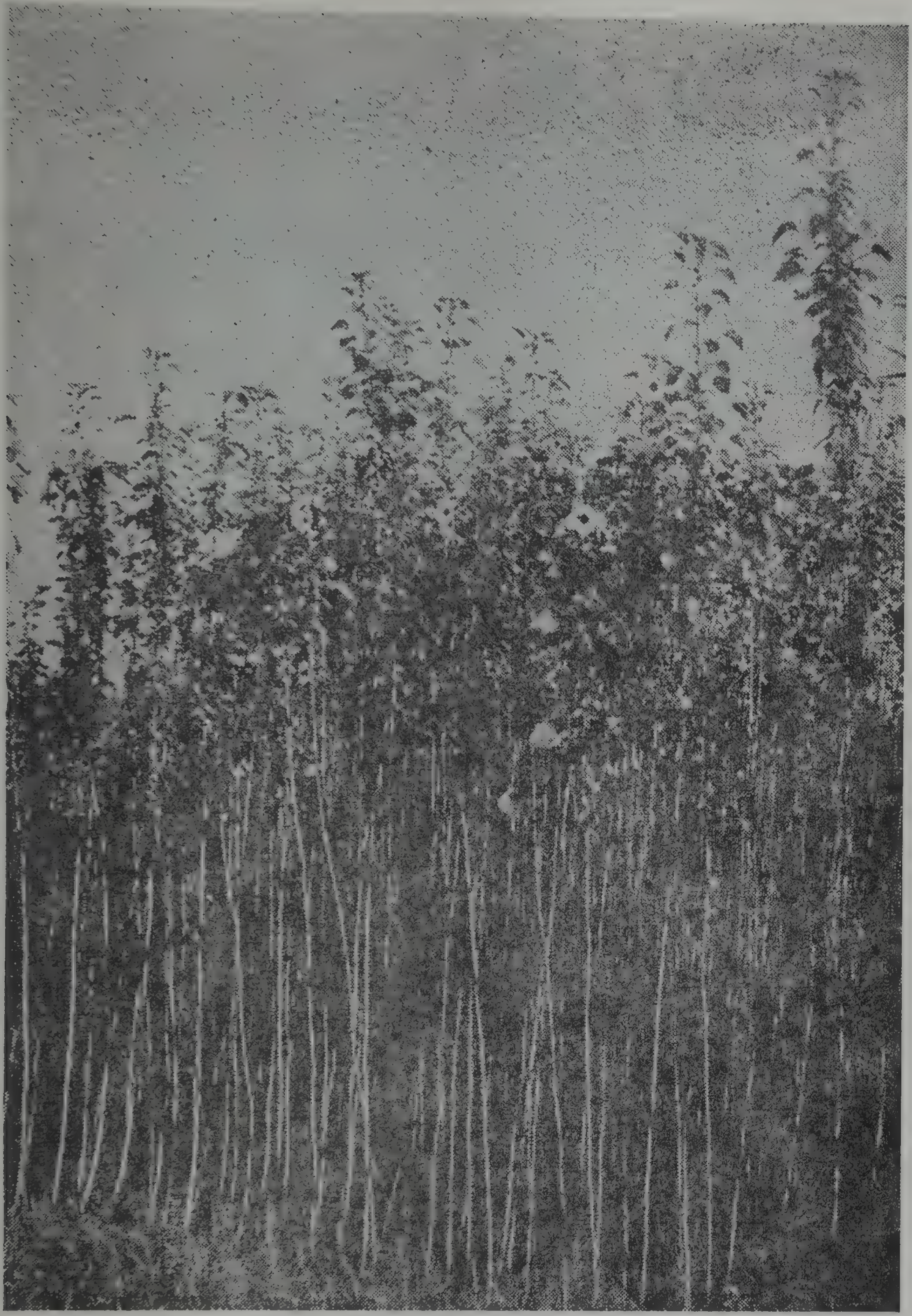


Fig. 2. B. Hibiscus cannabinus HC 583

quality, such delimitation of zones being based on data of various kinds gleaned through years.

The Nine Zones

Each of the zones has its own peculiarity. For example, Zone No. 2 is marked by early rains (late February), profuse precipitation, an acid soil which requires use of of lime or dolomite. This zone requires good quantity of magnesium as well, besides the usual NPK. The method of application of nitrogen in Zone 1 is top-dressing in two instalments, whereas in Zone 2 one-third of the nitrogen to be given, is better used as basal application and the balance as top-dressing in two instalments.

In Zone 7 and Zone 9 the crop in early phase invariably passes through a compratively long dry spell; for these two Zones foliar spray of nitrogen in the form of urea in water is recommended. The details have been elaborated elsewhere.

It is hoped that these nine zones will each be efficient producer of jute in soonest possible time.

Research on Weed Control

Weed control accounts for 33–40 per cent of the total cost of cultivation in jute. Strategy of weed control as is practised today is removal of weeds by raking during land preparation; this has to be as thorough as possible. Later when jute seedlings emerge there is simultaneous growth of grassy weeds, intensity of growth of such weeds varying in different fields. Manual removal of the weeds, in at least two operations within forty days, is essential for good growth of jute. Weed growth in double and triple cropped fields is much less than in fields where jute alone is grown in a year.

In order to replace this costly, tedious and difficult job of manual removal of weeds, search for suitable chemical weedicides yielded results of very encourating kind; V.N. Saraswat of this Institute demonstrated that preplanting treatment with sodium 2, 2, 3, 3,—tetra-flouropropionate give the much desired initial freedom of competition from weeds to jute and later disodium methyl arsonate or monosodium methyl arsonate in combination with dalapon or alone can efficiently keep down latter growth of weeds if any.

In about a couple of years jute cultivation may prove less costly and tedious than it is to-day, with use of these chemical weedicides and probably the wheel hoe.

Multiple Cropping

It has been amply demonstrated that jute will not compete with the major food crop—the transplanted paddy. Besides, in a bid to maximise production of food and fibre and to meet the food crisis various cropping patterns have been evolved on the basis of experimental results obtained during the last decade. A brief account of the patterns and the yields may be of interest.

1. Jute (25–30 q) : Paddy (50-60q) : Wheat (30–36 q).
2. Jute (20–25 q) : Paddy (50–60 q) : Paddy (50–60 q).
3. Jute (30–35 q) : Paddy (50–56 q) : Potato (150–170 q).
4. Moong relayed with Jute (7–8+30–35 q): Paddy (45–50 q): Potato (150–170 q).

The jute varieties involved were JRO 878; JRO 7835; the paddy varieties were IR-8, Jaya, CR 44-1, Ratna and Vijaya; the wheat varieties were—Kalyan Sona or Sonalika. For potato, Kufri Chandramukhi, Up-to-date and K. Sinduri were used. The moong variety was "Baisakhi."

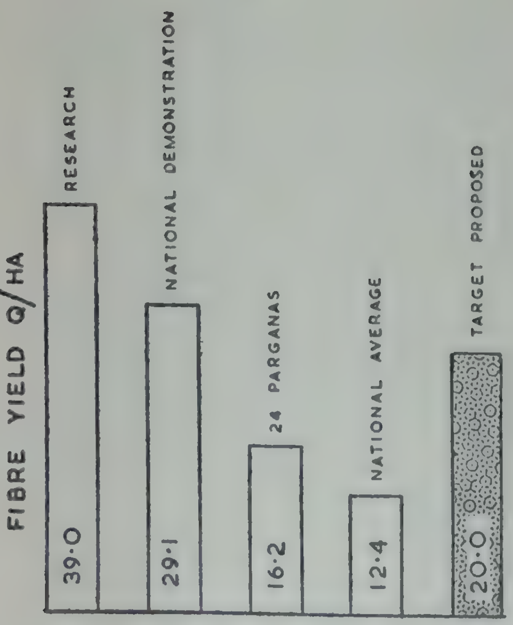
Yet other patterns involving mustard and vegetables have been worked out where the yield of mustard was around 12 q/ha.

Quality

If anything tortured most the mind of the jute industry during the last twenty years it is the question of quality of Indian jute.

Although quality depends on variety soil and climate, the most important single factor that governs quality of jute is the process of retting.

Fig. 3.



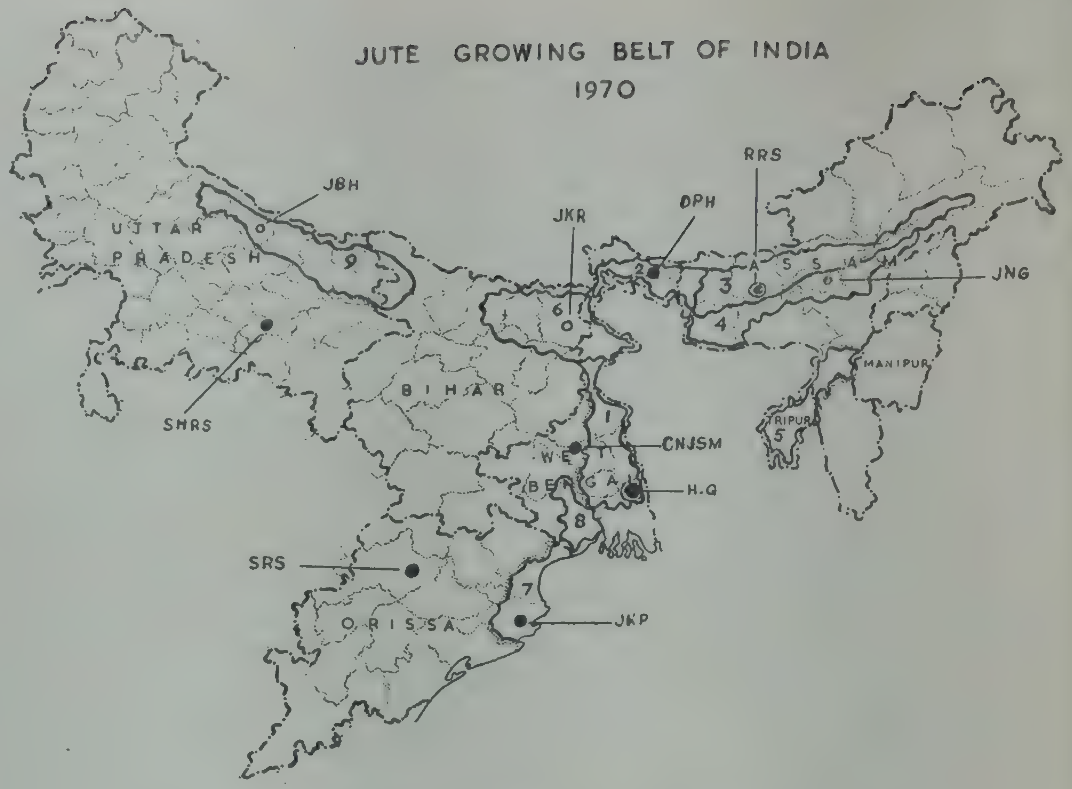


Fig. 4. 1-9, the nine jute zones and Jute Research Stations

Improvement in quality of jute fibre required proper elucidation of the process of retting. This has been done; the biological process of retting has been explained and recommendations formulated accordingly.

Thus, slow flowing clear soft water has been found to be best for retting. Elsewhere in case of stagnant pools, the ratio of plant to water should be 1:20. Influence of dissolved salts, pH, tannins and end products of the biological activity itself, has been elaborated.

Since, large volumes of clear water remained the very basis of good retting and such facility being not easily available in most of the jute growing areas, research is being continued to reduce the requirements of water.

Instruments have been devised to take out the fibre containing bark from the whole plant; this bark or ribbon consttitute only 41 per cent of the total volume of the plant. Retting of ribbons have now been perfected and is a possibility. The next step is designing and manufacture of the ribboning machine which the Institute is now aiming at.

Direct decortication of fibre from the green stem has also proved a possibility, machine for which has been designed by the Institute. Work is now proceeding to assess the quality of decorticated fibre as against those obtained by the traditional process.

Plant Protection

One of the major contribution coming out of the last twenty-five years of studies on diseases caused in jute by the fungus *Macrophomina phaseoli* (Maubl) Ashby is the finding that curative measures are not so effective as prophylaxis.

It has been possible to reduce and also to stop incidence of stem and root rot by correction of soil acidity, application of potash and by improving soil organic matter content. The seed treatment with organo-mercuric compounds and non-mercurials like Captan, Voronit and Dithane M45 have been found effective.

Colletotrichum gleosporioides has been recorded as a new parasite establishing itself firmly on *olitorius* varieties in Assam, while spread of *C. corchorum in capsularis* varieties has been checked by withholding susceptible types from an inadvertent entry into the programme for breeding high-yielding types.

The mode of transmission of leaf mosaic virus in jute has been traced in pollen and seed. This finding has helped keeping the foundation seed free from virus through roguing in early stages. Research workers have however noted the presence of a vector (white fly) which fortunately is still absent in seed producing tracts of Bihar, W. Bengal, U.P., M.P. and Maharastra. This vector is affecting the *Capsurlaris* crop in humid Assam. Search continues for resistant types.

'Hoogly wilt' of jute remains the most eluding problem. It is a serious disease, restricted to fields growing jute and potato in turn. This requires the concentrated attention of pathologists and chemists.

N. Mukerjee elaborated the foot and stem rot disease in mesta with precision, which helped evolving a control measure accepted by cultivators.

In the field of pest-control work of N. Dutta and R.L. Tripathi between 1948 and 1972 paved the way to evolving the most successful, economic and popular control measures against major jute pests like the black 'apion', yellowish green 'semilooper', orange coloured 'hairy caterpillar', yellow mite and nematodes.

The control schedule has been fully elaborated and demonstrated; it includes use of Endrin, Endosulfan or limsulphur which gives fullest possible protection from all the pests of jute.

Since 1948 this Institute has primarily been engaged in researches on improvement of jute yield till the end of first plant period. During the second plan period the Institute initiated research on fibre crops like ramie, sunnhemp and sisal and still later on flax, urena and malachra in a systematic manner. A brief reference to work done on important ones are given below.

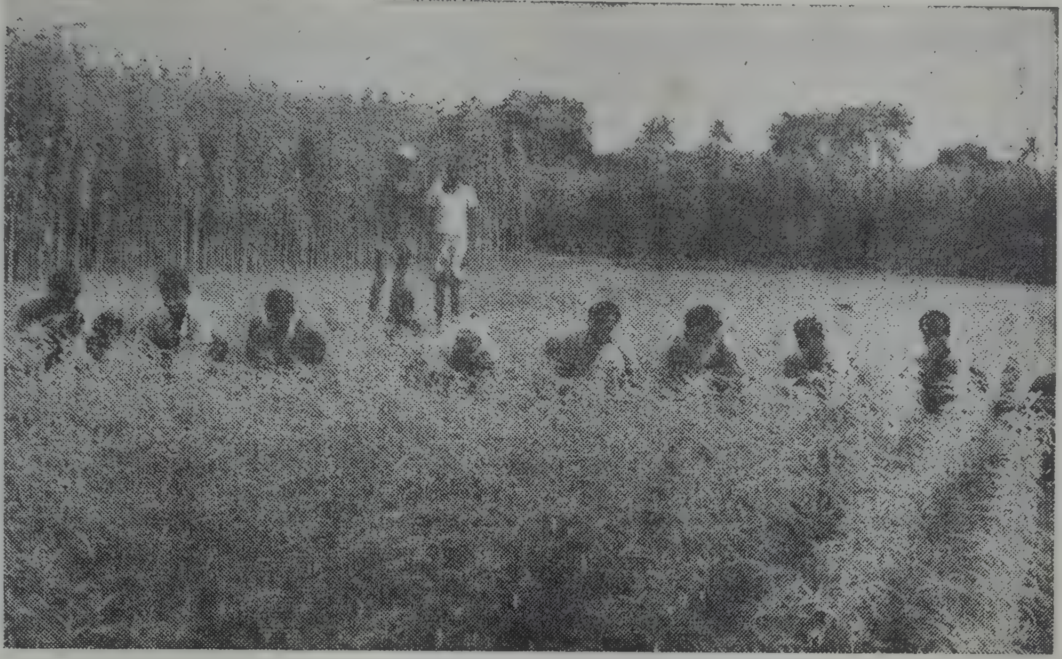


Fig. 5. Weeding in a jute field. The manual operation is tedious and costly

Ramie

One of the achievement of the Institute is the establishment and growth of the Ramie Research Station at Sorbhog, Assam. The station has, in a short period, evolved a high-yielding variety suitable for raising plantation in N.E. India. The technique of raising and maintaining a plantation has been published in a form of a bulletin.

Experiments and experience show that ramie, the strongest natural fibre, can be grown as a plantation crop in Assam, Nagaland, Aurnachal Mizoram, North Bengal, Meghalay and probably Tripura. The tea gardens may utilize the surplus land with good results; the economics of a plantation show that one may expect a profit of Rs 24,000 from one hectare in five years. The internal market has a good demand for this fibre. Much of our needs to import cotton can be curtailed if ramie plantations could be organized in a systematic manner.

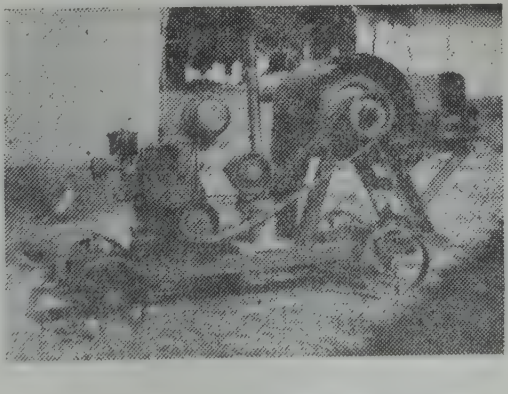


Fig. 6. The all purpose Decorticator

One of the primary requirement towards success in running a ramie plantation is the availability of efficient decorticating machine, which extracts the fibre from ramie canes. This Institute has designed and produced the prototype machine which is now ready for manufacture.

Sunnhemp

Export of sunnhemp from India has recently been greatly reduced while internal consumption by paper industries has increased. The Industry requires more. Unfortunately, there has been no standard improved type of this highly cross pollinated sunnhemp crop till we established the Sunnhemp Research Station at Pratapgarh. Today, the K12 yellow and K12 black evolved at S.R.S., Pratapgarh are the only two improved types. As a short-term measure the agronomy to increase yield up to 7 quintals per hectare, has been worked out; as a long term measure the plant is being studied to understand its genetical behaviour regarding inheritance of characters.

To keep sunnhemp in its proper

Fig. 7. Ramie crop

position as a source of fibre, the only way out is to increase the yield per unit area, as it is facing serious competition from high-yielding cereals.

Multiplication of seed in isolation being an important prerequisite for maintaining purity, foundation seed is now being multiplied at Jetsar, Rajasthan.

Sisal fibre is obtained from leaves of *Agave sisalana* and is largely used for making marine cordage, brushes, mattress, etc. There is a possibility to use it for paper making and reinforced hard boards.

Our requirement of sisal fibre today is met largely by imports from Africa. The ICAR has established the Sisal Research Station at Bamra, Orissa in 1962 to stabilize sisal cultivation in India on scientific lines.

Fig. 8. A Sisal crop in Bamra

Accordingly, the agronomy has been worked out and the Sisal Research Station is now functioning as the supplier of planting material and technical guidance for planters in private and public sector, besides conducting research on agronomy and plant protection.

There are possibilities of growing sisal in India to make the country at least partially self sufficient; Orissa, M.P. and Chotanagpore holds big promise.

Researches during the sixties demonstrated that unless climatological requirements are precisely fulfilled, flax growing will be unprofitable in India. Flax type selected and improved by JARI has proved to be a success in Himachal Pradesh and it now requires some effort to popularize the technique with farmers. The scutching machine which is a must with a flax cultivator, has been designed and prototpye is ready for the manufacturer.

The same machine can salvage the fibre that goes waste with linseed straw.

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RECLAMATION AND UTILIZATION OF SALT-AFFECTED SOILS

D.R. BHUMBLA
Director, Central Soil Salinity Research Institute, Karnal

It is estimated that India has about 17 million acres of salt affected soils. These soils may have the problem of only high salt (E.C.e 4 mmhos) or of high alkalinity (pH 8.5) or both. It was in the year 1855 that complaints about the development of salinity were made by the farmers of the areas irrigated by Western Jamuna canal in Haryana. Since then a number of Committees have submitted their reports. To mention a few—Reh Committee (1877), Water-logging Committee for Nira Canal area in Maharashtra (1903), Water-logging Enquiry Committee Punjab (1924). A special division in P.W.D. was created at Baramati in 1916 to conduct research on drainage. Irrigation Research Institute, Lahore (now in Pakistan) was established in 1925 for detailed studies on the problem of water-logging and salinity. The methods evolved were either not very effective except for the conditions of the station where they were developed or they were expensive.

Little Early Information

In 1947, when the country became independent, very little information on the reclamation and utilization of these soils was available. A few experiments in Punjab and in Deccan had indicated that application of gypsum was useful but the returns reported were marginal and the rate of improvement was so slow that it was not thought practical to try reclamation in soils with a pH of more than 9.4. The only method recommended was leaching of salts by growing rice and berseem in rotation.

During the period 1950-1960 number of studies on the nature of salt affected soils of the Indo-gangetic plains of Punjab, Delhi and Uttar Pradesh were made which indicated that in soils of this region the main problem was of very high alkalinity and consequent poor physical conditions.

In U.P. where the problem is acute, Reclamation Farms were started by the Department of Agriculture in Lucknow (Rahimabad) and Hardoi (Dhakauni and Katiar) districts, where leaching along with addition of rice straw were stressed. Similar farms were started in Haryana (Nising) by the Irrigation Department where growing of dhaincha as a green manure as a reclamative crop was recommended. The research work at Kamma in Ludhiana district of Punjab clearly showed that most of these deteriorated soils were deficient in nutrients and organic matter. Application of fertilizers was reported to result not only in increased yields but also hastened the process of reclamation. But at Nilokheri in Karnal district where the soils were highly deteriorated and water-table was high application of nutrients alone was not at all helpful.

In the coastal deltaic areas where inundation from sea water was common, the main stress was on breeding salt resistant varieties of rice. SR-26 B was reported to be tolerant to salinity. In West Bengal Rupsala, in Andhra Pradesh MCM-1 and MCM-2 in Tamil Nadu PVR-1, in a Kerala Pokali and in Maharashtra Bhura Ratta and Kala Ratta varieties of rice were claimed to be more tolerant than others. Similar claims were made for *Kharchia* variety of wheat in Rajasthan. But all these varieties had low yield potential.

Work at I.A.R.I. on saline soils by late Dr Bains and his colleagues showed that the method of planting and other agronomic practices like the addition of nutrients could result in high yields of tolerant crops like barley, berseem and *sarson* on such soils.

Two of the main drawbacks in the work on salt affected soils have been :—

(1) The problem has been considered in isolation either as a problem of Drainage Engineer or of Soil Chemist or of Agronomist or of a Plant Breeder. Inter-disciplinary approach where scientists of different disciplines could work together to find some solution to the problem was lacking.

(2) The salt affected soils vary a great deal in their physico-chemical properties. Technology developed under one set of condition cannot be applied under all conditions. Such attempts to import technology were made but the results were disappointing.

Realising the seriousness of the problem of soil salinity and alkalinity and the likely danger of its further spread in the new areas coming under irrigation the Government of India established the Central Soil Salinity Research Institute under the Indian Council of Agricultural Research. The Institute started functioning at Karnal in Octber 1969. The Rice Research Station at Canning which was formerly with the CRRI, Cuttack was also transferred to the Institute in 1970.

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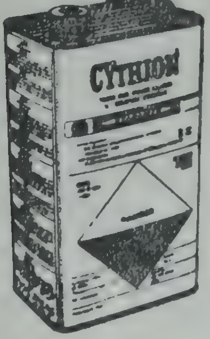

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During the last three years the Institute conducted a number of experiments and some of the important findings of the Institute for the reclamation and utilization of salt affected soils are given below.

Leaching Of Salts

Leaching salts to lower layers beyond the root-zone of shallow rooted crops can be accomplished by ponding water on the soil surface. The best time for leaching salts would be when the ground water-table is deep or receding. In the Indo-gangetic plains the water-table is deepest in June. It is, however, not always possible to leach the salts beyond the rootzone because the soils are highly impermeable and do not permit the entry of water. Under the such conditions it becomes essential to improve soil permeability. Addition of gypsum considerably facilitates water penetration and therefore salt leaching. (Fig. 1, 2). In highly deteriorated soils if it is intended to push the salts below 30 mm a total of 60 cm water will be needed. Advantage can be taken of rain water along with aplication of rice husk as a mulch at the surface. This practice would reduce the upward movement of salt.

Application of Gypsum

In highly alkali soils of Indo-gangetic plains addition of gypsum for the improvement of alkali conditions is very important. The research work at the Central Soil Salinity Research Institute during the last 3 years was aimed at finding the optimum quantity of gypsum for such soils. Results of one such experiment are given in Table 1.

TABLE 1. EFFECT OF THE APPLICATION OF GYPSUM ON THE YIELD OF DIFFERENT CROPS

Gypsum Tonnes/ha	*Grain Yield q/ha*					
	1970–71			*1971–72*		
	Paddy	*Wheat*	*Barley*	*Paddy*	*Wheat*	*Barley*
0	2.37	0.43	0.40	68.2	31.7	38.6
7.5	14.31	16.40	22.08	68.2	36.3	40.7
15.0	27.66	28.10	25.85	74.8	40.2	42.7
22.5	30.96	34.05	29.27	71.3	37.7	47.3
30.0	34.17	37.90	33.18	72.3	38.7	48.8

This land had been lying uncultivated for many decades due to serious salinity and alkalinity trouble (pH 10.2). Gypsum requirements as determined in the laboratory were 60 tonnes/ha. The studies clearly showed that for shallow rooted crops application of gypsum at the rate of 1/4 of the gypsum requirement was adequate. Another significant observation is that for saline alkali soils of Indo-gangetic plains wheat is as good a crop as barley. The cost of gypsum is recovered in the very first year. Unlike fertilizers gypsum is to be added only once. Even in the second year the yield or the treatment where gypsum was added at the rate of 15 tonnes yield of wheat was 9 quintals more than that of untreated plot.

Nutrients N. Alkali soils are deficient in nutrients particularly nitrogen and zinc. Of the nitrogenous fertilizers ammonium sulphate is a better fertilizer than urea or calcium ammonium nitrate. (Table 2).

TABLE 2. EFFECT OF DIFFERENT NITROGENOUS FERTILIZERS ON THE YIELD OF WHEAT

Rate of N (kg/h)	*Grain yield of wheat (Kalyan Sona) q/ha*		
	Ammonium sulphate	*Calcium ammonium nitrate*	*Urea*
60	34.9	31.8	32.0
90	40.0	38.2	34.4
120	50.0	47.3	41.0
150	62.9	59.0	52.7
180	63.7	57.6	56.8

Micronutrients. In highly sodic soils the availability of micronutrients like zinc, manganese and iron is very much depressed. Experiments were conducted to study the effect of the application of zinc in presence and absence of farmyard manure on the yield of paddy and berseem. It would be observed that application of zinc resulted in appreciable increase in the yield of crops. The increase in yield was more in absence of farmyard manure than in its presence indicating that addition of farmyard manure results in enhanced availability of micro nutrients. (Table 3)

TABLE 3. EFFECT OF THE APPLICATION OF ZINC FARMYARD MANURE AND GYPSUM ON THE YIELD OF PADDY AND BERSEEM

Treatment	*Yield q/ha*			
	Paddy (Grain)		*Berseem (Green fodder)*	
	O Zn	*Zn*	*O Zn*	*Zn*
Control	54.2	72.1	608	771
Fym 25 tonnes/ha	66.1	78.3	834	855
FyM 50 tonnes/ha	76.7	84.5	897	975
Gypsum 11 tonnes/ha	66.9	88.6	1002	1076
Gypsum+FyM 25 tonnes	77.4	92.2	1100	1118
Gypsum+FyM 50 tonnes	83.8	88.9	1129	1148

Agronomic Practices. Management of highly alkali and saline soils calls for different agronomic practices. Unlike normal soils deep ploughing and puddling are harmful practices. Tillering of crops like rice and wheat in highly saline and sodic soils is poor. To compensate for this poor tillering higher plant population is essential. In an experiment at CSSRI farm Karnal planting 4 plants per hill instead of 2 resulted in increasing the yield of paddy by about 8 quintals.

Water Management. In highly saline and sodic conditions the permeability of the soil is very poor. Under such conditions if heavy irrigation is given the water continues to stand in the field for days and thus affects the crop growth adversely. Experiments conducted by the scientists in C.S.S.R.I. have shown that frequent light irrigations are better than heavy irrigation (Table 4).

TABLE 4. EFFECT OF FREQUENCY OF IRRIGATION ON THE YIELD OF WHEAT GROWN ON A SALINE SODIC SOIL

Treatment (irrigation applied at indicated cumulative evaporation)				*Grain yield (q/ha)*	
1970–71		1971–72		1970–71	1971–72
(Emm)	*(No. of irrigation)*	*(Emm)*	*(No. of irrigation)*		
40	11	30	14	19.9	26.3
60	8	50	9	14.6	25.7
80	6	70	7	9.6	23.2
100	5	90	6	7.8	20.4
120	4	110	5	6.8	14.6

Choice of Crops and Crop Varieties. The crops differ a great deal in their tolerance to salinity and alkalinity. The work at the Institute has shown that during kharif rice is to be preferred over other crops for saline sodic soil conditions because of its shallow root system and high flooding tolerance. Legumes like cowpeas, moong are very sensitive. High-yielding varieties like IR. 8 and Jaya are better suited because of their high yield potential.

Amongst the sugarcane varieties tried Co 453, Co 975 and B 37172 have given higher yield than others.

In rabi wheat and barley give better yield than other crops. Wheat is better crop than barley in the Indo-gangetic plains.

Brassica juncea gives better yield than other oil seed crops.

Sugarbeet in these soils gives as good yield as in normal soil when proper agronomic practices are followed but the main problem is marketing.

Quality of Irrigation Water. The Institute conducted detailed investigations on the chemical composition of well waters of Mathura district of U.P. and Jind district of Haryana. It was observed that standards for judging the quality of irrigation water as fixed in other countries are not applicable in monsoon type of climate. The Institute sponsored a meeting of senior research scientists working on this problem in Punjab, Haryana, Uttar Pradesh, Rajasthan, Gujarat and CAZRI, Jodhpur. After thorough discussions broad guidelines for judging the quality of irrigation water were evolved and recommended for adoption. This new classification takes into consideration not only the water but also the soil and the crop to be grown. Whereas, in heavy textured soil for semi-tolerant crop the maximum permissible limit of electrical conductivity of water is 1500 micromhos in light textured soil a water with an electrical conductivity of 8000 could be used for tolerant crops.

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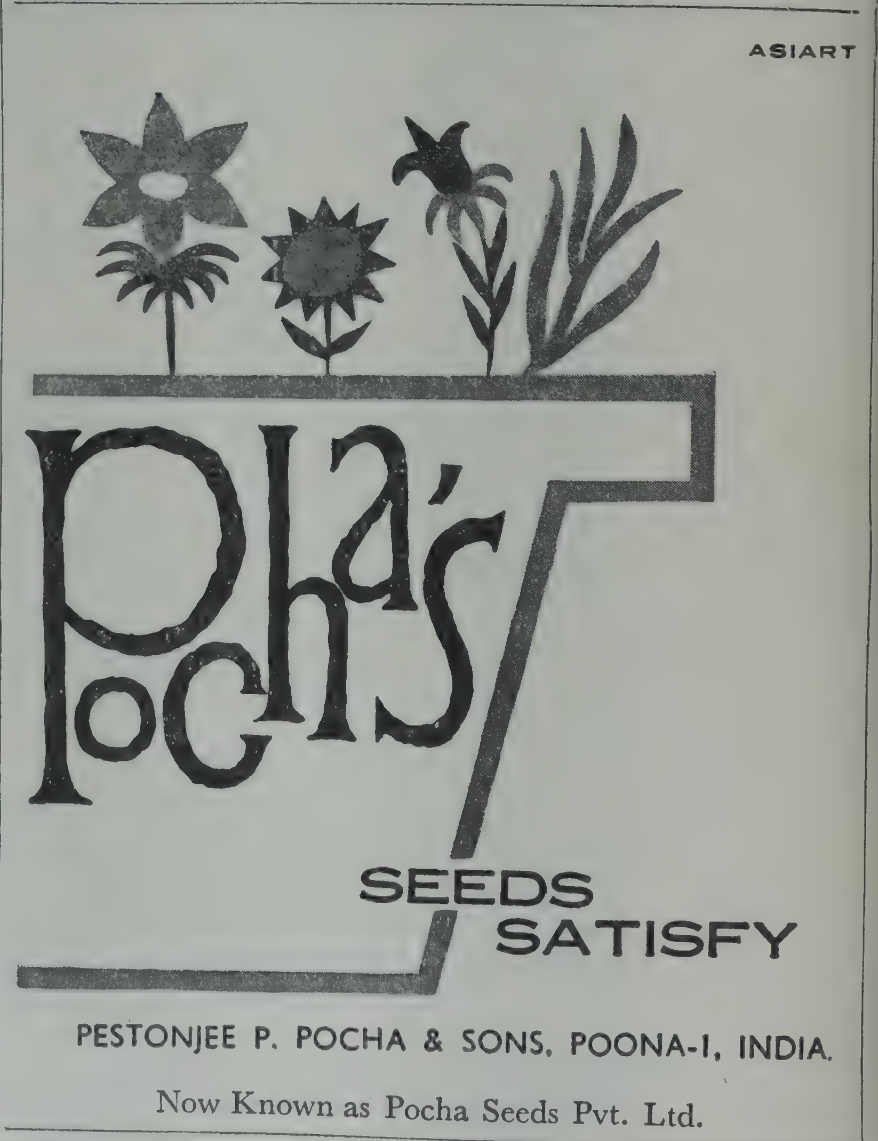

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ROLE OF ALL INDIA CO-ORDINATED AGRONOMIC EXPERIMENTS SCHEME

I.C. MAHAPATRA, RAJENDRA PRASAD, N. N. GOSWAMI
and M.G. SARDANA
All-India Coordinated Agronomic Experiments Scheme, I.C.A.R.,
New Delhi

AGRICULTURAL research and development is a continuous process and coordinated research on a national scale has become a very important component in India's strategy in rapid agricultural development. This approach has proved to be extremely effective in: (a) efficient utilization of research resources for developing new technology locally and (b) testing, adapting and incorporating new technology in order to maintain a rapid growth rate in agricultural production.

The All-India Coordinated Agronomic Experiments Scheme (AICAES) is not only the biggest and the most comprehensive coordinated scheme in the country, it is also the oldest. It has the organization, experience, adaptability and scope which allow it to quickly and effectively adapt and orient research to the problems of the time or the region in every part of the country while at the same time providing information which allows planners to keep their finger on the pulse of new developments and allocate generally scarce resources for maximum benefit.

The AICAES, unlike most other Coordinated Research Schemes was initiated before the large scale introduction and adaptation of modern agricultural technology recognizing the substantial contribution that fertilizers and other agronomic practices could make towards raising the yield levels of crops in the country. Indian Council of Agricultural Research initiated this scheme in 1950, with the expert advice of Dr A.B. Stewart of Macaulay Institute of Soil Research, Aberdeen, Scotland, a scheme under which a series of three-plot trials were conducted on cultivators' fields in seven States. This scheme extended over three years. In the light of the experience gained, a revised scheme for conducting fertilizer experiments on cultivators' fields was initiated by the Ministry of Food and Agriculture in March, 1953 under the "Soil Fertility and Fertilizer Use Project". This scheme was started with the assistance of Technical Cooperation Mission of the U.S.A. and continued up to February, 1956. Under this scheme 5397 simple fertilizer trials were carried out on rice and wheat in 22 community project areas. Alongwith these 304 complex agronomic experiments were also conducted on rice and wheat at 18 selected centres.

Results obtained under "Fertilizer Use Project", were useful and encouraging and it was decided by I.C.A.R. to extend these experiments to other crops and areas. A more comprehensive scheme taking into cognizance the agricultural problems which would arise on the completion of different large scale irrigation projects was launched by I.C.A.R. in 1956 known as "All India Coordinated Agronomic Experiments Scheme".

During the Second Plan period complex factorial experiments were conducted at 34 centres to study the response of different crops especially rice and wheat to nitrogen, phosphorus and potassium as affected by dates of sowing and method and time of fertilizer application. The Simple Fertilizer Trials, during this period, were also conducted in 90 districts to determine the response of different field crops to nitrogen, phosphorus and potassium and to study the relative efficiency of different nitrogen fertilizers for cereals and the relative efficiency of different phosphatic fertilizer for legumes and their residual effect on following cereal crops.

During the Third Plan period the earlier complex experiments were continued and new experiments namely, the response of crops to micronutrients, foliar vs. soil application of plant nutrients, transplanting of wheat and comparative efficiency of DDA and PEC nitrophosphates were taken up. The number of centres was increased to 48. The technical programme of the Simple Fertilizer Trials Scheme during this period was also modified to study the response surfaces for different crops to nitrogen, phosphorus and potash. Besides, jute crop was also included in the programme. The number of districts under the Scheme was increased to 170.

During Fourth Plan period the scope of the work under the scheme was further enlarged. The work at the moment is in progress at 43 Model Agronomic Centres and in 55 districts. Out of these 35 districts are under High-Yielding Varieties Programme and 20 under Dry Farming Programme. At a Model Agronomic Centre about 15-20 experiments are conducted each year. The targetted number of trials for S.F.T.high-yielding varieties programme districts are 212 and for S.F.T. dry farming programme are 144 per year.

The main objectives of the experiments conducted at the Model Agronomic Centres are.

(i) To determine the production potential in different agro-climatic regions of the country under optimum input conditions as well as under resource constraints operating in the area.

(ii) To develop intensive farming systems for small holdings in different agro-climatic regions of the country.

(iii) To study the possibilities of increasing production by inter-cropping in widely spaced crops.

(iv) To obtain information on the response of high-yielding varieties of cereals to different agronomic factors such as, fertilizer (including micronutrients), irrigation, dates of sowing, plant population, spray fertilization, weed control, liming, etc.

(v) To study the manurial requirements of important crop rotations and their effect on soil fertility.

(vi) To evaluate new nitrogen (including slow-release materials) and phosphatic fertilizers for different crops and areas.

The main objectives of the simple fertilizer trials are:

(i) To study the responses of high-yielding introduced and locally improved crop varieties to nitrogen and phosphorus applied alone and in combination and to potassium in the presence of nitrogen and phosphorus under irrigated as well as dryland conditions.

(ii) To compare different methods of application of nitrogen on cereals under dry farming conditions.

(iii) To study the relationships between crop soil tests and response to fertilizers.

This is the only project which provides direct link between experimental stations and cultivators' fields for evolving suitable *location specific agronomic technology.* The technical programme of the scheme is drawn up at its annual workshops where the scientists from all the states participate. The design of the experiments is kept flexible to accommodate modifications to meet local needs.

The Project has a full-time Co-ordinator who is assisted by supporting staff in Agronomy, Soil Science and Statistics. At state level also a full time scientist is provided to superivise the work of the project. He has also supporting staff for chemical and statistical analysis. For each Model Agronomic Centre and Simple Fertilizer Trials district an Asstt. Agronomist/Chemist is provided who has supporting field staff. S.F.T. districts under High-Yielding Varieties Programme are also provided with a vehicle. In all 717 scientific workers (138 senior staff and 579 junior staff) are working in the project.

Highlights of Results

The results obtained under the All-India Co-ordinated Agronomic Experiments Scheme are brought out in the form of annual reports and it is beyond the scope of this article even to summarize these. Important results of practical utility obtained since the introduction of High-Yielding Varieties Programme, i.e. during the years 1967-68 to 1970-71 are given below:

High-yielding varieties perform better than local varieties at native as well as high soil fertility.

The high-yielding varieties of rice (IR-8, Padma and Jaya), wheat (Kalyan Sona, Sonalika and Sharbati Sonora); hybrid maize (Ganga-2, 3 and 5) and bajra (Hybrid HB-1, and 3) are distinctly superior in terms of both yield and net return per rupee invested, to local tall varieties at higher level of fertilizer application. Even at native soil fertility they give as good as or even better yields than the tall ones. It is observed that in case of high-yielding varieties of rice with 120 kg N, 60 kg P_2O_5 and 60 kg K_2O a net profit of 113 to 289 per cent on investment on fertilizer was obtained, whereas with the tall varieties the net profit was only 40 to 60 per cent at most places. In wheat the net profit on fertilizer investment ranged from 150 to 450 per cent.

Some of the locally improved varieties also performed well in certain areas. These are: rice varieties—BR-34 in Shahabad (Bihar), Safri-17, in Raipur (M.P.); ADT-27 and CO-33 in Thanjavur district (Tamil Nadu), CO-29 in Chittoor district (Andhra Pradesh) and HR-35 in Raichur district (Mysore); wheat varieties—NP-884 in Monghyr and Shahabad and Hybrid-65 in Hoshangabad district; and maize varieties, Jaunpur Safed in Monghyr and Him-123 in Mandi district, Himachal Pradesh.

TABLE 1. CROPPING SEQUENCES FOR HIGH GRAIN YIELD IN DIFFERENT AREAS

Centre	*District*	*Year*	*Rotation* (*Two or three crop one year rotation*)			*Total cropped days (cropped days with grain crop)*	*Production kg/ha (grain)*	*Grain Production cropped day (kg/ha)*
			Kharif	*Rabi*	*Summer*			
1	2	3	4	5	6	7	8	9
Tirupati	Chittoor	1970–71	Rice (IR.8)	Rice (IR-8)	Rice (Hamsa)	334	14338	43
		1969–70	Rice (Hamsa)	Rice (Hamsa)	Rice (IR-8)	343	13819	40
		1968–69	Rice	Rice	Rice	361	14356	39
Pura Farm	Kanpur	1970–71	Maize (Ganga-5)	Wheat (K Sona)	Cowpea (Fodder)	285 (228)*	8883	39
		1969–70	Maize (Composite)	Wheat (S-227)	Cowpea (Fodder)	337 (227)*	10257	37
Varanasi	Varanasi	1970–71	Rice	Wheat (S. Sonora)	Rice	332	13083	39
Hissar	Hissar	1970–71	Bajra (HB-1)	Wheat (K-227)	Maize (Fodder)	323 (254)*	8078	32
		1970–71	Maize (Viraya)	Wheat (K-227)	Maize (Fodder)	323 (254)*	8211	32
Maruteru	W. Godavari	1970–71	Rice (Pankaj)	Rice (Padma)	Rice (Kavari)	314	12253	39
		1969–70	Rice (IR.5)	Rice (Jaya)	Mung	271	12088	45
Kathulia Farm	Rewa	1970–71	Maize (Ganga-3)	Wheat (RR-21)	Cheena (Local)	306	14702	48
		1969–70	Maize (Ganga-3)	Wheat (K. Sona)	Cheena (Local)	302	15275	47
Bhavanisagar	Coimbatore	1970–71	Rice (ADT-27)	Rice (IR-8)	Maize Hi-stach)	313	13108	42
Bichpuri	Agra	1970–71	Maize (Ganga-5)	Wheat (HD-1553)	Bajra (Fodder)	301 (233)*	10776	46
Pantnagar	Nainital	1969–70	Maize (Ganga-3)	Wheat (RR-21)	Cheena (Local)	304	11707	37
		1968–69	Maize	Wheat	Cheena	298	14333	48

*Figures in parenthesis in Column 7 indicate the number of cropping days occupied by the grain crops only.

Response to Nitrogen

Response to nitrogen was universal up to 120 kg N-ha in all the 17 districts where trial with rice were undertaken and it varied from about 500 kg/ha in Alleppey and Poona to 2100 kg/ha in Shimoga district. Higher responses to nitrogen (1500 kg/ha and above) were obtained in the districts of Thanjavur, Chittoor, Shimoga and Cuttack. Of a somewhat lower order but good responses (between 1000 to 1500 kg/ha) were also obtained in the districts of Nizamabad, Shahabad, Raichur, Raipur, Coimbatore, Varanasi, Burdwan, Palghat and West Godavari. Response to nitrogen was much higher in rabi than in kharif in the districts of Cuttack, Shimoga and Raichur while in Chittoor and Thanjavur responses were more during kharif.

In case of wheat also, response to nitrogen was universal in all the 16 districts where trials with wheat were undertaken and it varied from 293 kg/ha in Mandi to 1864 kg/ha in Aligarh district. Higher responses to nitrogen (1500 kg/ha and above) were consistently obtained in Shahabad, Delhi, Karnal, Kanpur and Aligarh. Of a somewhat lower order, but good responses (1000 to 1500 kg/ha) were also obtained in Hoshangabad, Ludhiana, Varanasi and Burdwan.

Response to Phosphorus

Consistent responses of rice to phosphorus at 60 kg P_2O_5/ha, either alone or over 120 kg N/ha, were obtained in all the districts except Raipur, Poona and Cuttack and it varied from about 350 kg/ha in Varanasi and Plaghat to 1400-1500 kg/ha in Shimoga and Sambalpur. Higher responses (1000 kg/ha and above) were obtained in the districts of Shimoga, Thanjavur; Coimbatore, Sambalpur, Chittoor, West Godavari and Raichur, moderately high responses (500 kg/ha and above) in the districts of Nizamabad, Alleppey, Karnal and Shahabad, but low responses (below 500 kg/ha) in Burdwan, Palghat and Varanasi.

Similarly, in case of wheat, consistent responses to phosphorus were obtained in all the 16 districts where the trials were conducted, but the order of response to 60 kg P_2O_5 ha over 120 kg N/ha varied from 236 kg/ha in Mandi to 1269 kg/ha in Ludhiana district. Higher responses (1000 kg/ha) and above) were obtained in Ludhiana Hoshangabad and Delhi; moderately high responses (500 to 1000 kg/ha) in Aligarh, Nasik, Bhavnagar, Karnal, Shahabad, Mehsana and Kanpur; but low responses (below 500 kg/ha) in Pali, Varanasi, Burdwan, Jhansi and Mandi.

Response to Potassium

Consistent responses of rice to potassium were obtained in 9 out of 17 districts where the trials were conducted. Mean response to 60 kg K_2O/ha over 120 kg N+60 kg P_2O_5/ha varied from 115 kg/ha in Palghat to 702 kg/ha in Sambalpur district. Higher responses (500 kg/ha and above) were obtained in Sambalpur, Shahabad, Thanjavur, and Chittoor, moderate responses (250 to 500 kg/ha) in Shahabad, Nizamabad, Alleppey and Cuttack and less than 250 kg/ha in Palghat.

Similarly, in case of wheat, consistent responses to 60 kg K_2O/ha were obtained in 10 out of 16 districts but the response was generally low to moderate, varying from 112 kg/ha in Nasik to 299 kg/ha in Burdwan.

Response to Micronutrients

Significant response to foliar application of zinc having been consistently obtained at the Model Agronomic Centres located in the districts of Jammu, Nainital, Varanasi, Rewa and Kurnool, it is recommended that suitable doses of zinc may be applied to rice, wheat and maize in these districts.

Significant responses to application of manganese were also consitently obtained with rice and wheat at the Model Agronomic Centres, B.H.U. (Varanasi), Kathulia Farm and Tiripati located in the districts of Varanasi, Rewa and Chittoor, respectively (Table 4b). It is, therefore, recommended that manganese may be applied at suitable doses to rice and wheat crops in areas represented by these centres.

Soil test values and response of wheat to phosphorus and potassium

Results from 63 trials on cultivators fields (variety Kalyan Sona) in Kanpur district showed a good relationship between yield response to applied phosphorus and potassium and soil test for phosphorus and potassium and also with the other soil characteristics.

Responses of the order of 400-1000, 500-1600 and 600-2000 kg/ha were obtained to 30, 60 and 90 kg P_2O_5/ha, respectvely on different soil fertility status. Responses were the lowest on soils of high phosphorus status, intermediate on soils of medium phosphorus status and highest on low-phosphorus soils. The yield of no-phosphorus treatments increased with the increase in the initial phosphorus fertility status of the soil.

The soil types also differed in their response to phosphorus, Ganga uplands (Kanpur type-3) showed the highest responses followed by Central lowlands (Kanpur Type-4), Ganga lowlands (Kanpur Type-2) and Yamuna flats (Kanpur Type-5) in descending order. Significant responses to 90 kg P_2O_5/ha were obtained only on the first two soil types. Results clearly showed that profitable responses could be obtained up to 90 kg P_2O_5/ha on low phosphorus soils, belonging particularly to Ganga uplands and Central lowlands, and up to 60 kg P_2O_5/ha on medium phosphorus soils while 30 kg P_2O_5/ha would be adequate on soils of high phosphorus status. The critical level of soil phosphorus (Olsen method) is about 10 ppm P.

Responses to potassium were generally greater on Central lowlands and Yamuna flats and on soils of low potassium status. Forty kg K_2O/ha was an adequate dose for soils testing low to medium in potassium while application of potassium was not necessary on soils of high initial potassium fertility (Table 5b).

Fertilizer responses in dry farming areas

From the results obtained in 1970-71 with rice (134 trials) in Allahabad, Jabalpur and Mayurbhanj; with wheat (370 trials) in Allahabad, Ambala, Gwalior, Hoshiarpur, Jabalpur, Jalaun, Mayurbhanj and Koraput; Aurangabad, Bijapur, Sholapur, Hyderabad and Kurnool; with maize (193 trials) in Hoshiarpur, Ambala and Panchmahal; with bajra (236 trials) in Jamnagar

Aurangabad, Sholapur and Ramanathpuram; with gram (118 trials) in Panchmahal, Gwalior and Mayurbhanj; with groundnut (106 trials) in Bijapur, Mayurbhanj, Ramanathpuram and Koraput and with castor (28 trials) in Hyderabad, the following points emerged out:—

1. Good response to nitrogen is obtained up to 50 kg N/ha in case of rice, wheat and maize and an application of this level of nitrogen may be recommended for these crops.
2. On phosphorus deficient soils phosphorus fertilization is a must even under rainfed conditions. In a large number of experiments with wheat, maize and jowar application of 25 kg N and 25 kg P_2O_5/ha gave better responses than 50 kg N/ha. Cultivators in dry farming areas apply very little fertilizer and if at all, they apply only nitrogen. If phosphorus is not applied, the cultivator may even lose in what he applies as nitrogen. The results clearly bring out that in dryland agriculture soil fertility status may be as limiting as moisture.
3. For crops like gram, groundnut and castor both nitrogen and phosphorus fertilization are important.
4. Moisture conservation practices such as deep ploughing and bunding should be followed.

Multiple cropping for high grain yields

Experiments showed that production levels of 14.3 tonnes/ha with rice—rice—rice (at Tirupati), 13.1 tonnes/ha with rice-wheat-rice (at Varanasi) and 15.3 tonnes/ha with maize-wheat-cheenar (at Kathulia farm) were obtained in a year. The detailed data are presented in Table 1.

Relative efficiency of nitrogenous fertilizers

Ammonium sulphate, ammonium sulphate nitrate, calcium ammonium nitrate, urea and ammonium chloride were found to be equally good for wheat. In case of rice, however, the results indicated that nitrate containing fertilizers were slightly inferior to ammonium containing fertilizers or urea.

Relative efficiency of phosphatic fertilizers

Although, in general, mono ammonium phosphate and single super phosphate were equally effective, in some of the experiments particularly those on heavier soils the response to mono-ammonium phosphate was higher. For grain legumes super-phosphate was a better source. On neutral to alkaline soils, nitro-phosphates gave lower responses as compared to single superphosphate, but on acid soils nitro-phosphates performed well. Urea ammonium phosphate and superphosphate were found to be equally effective.

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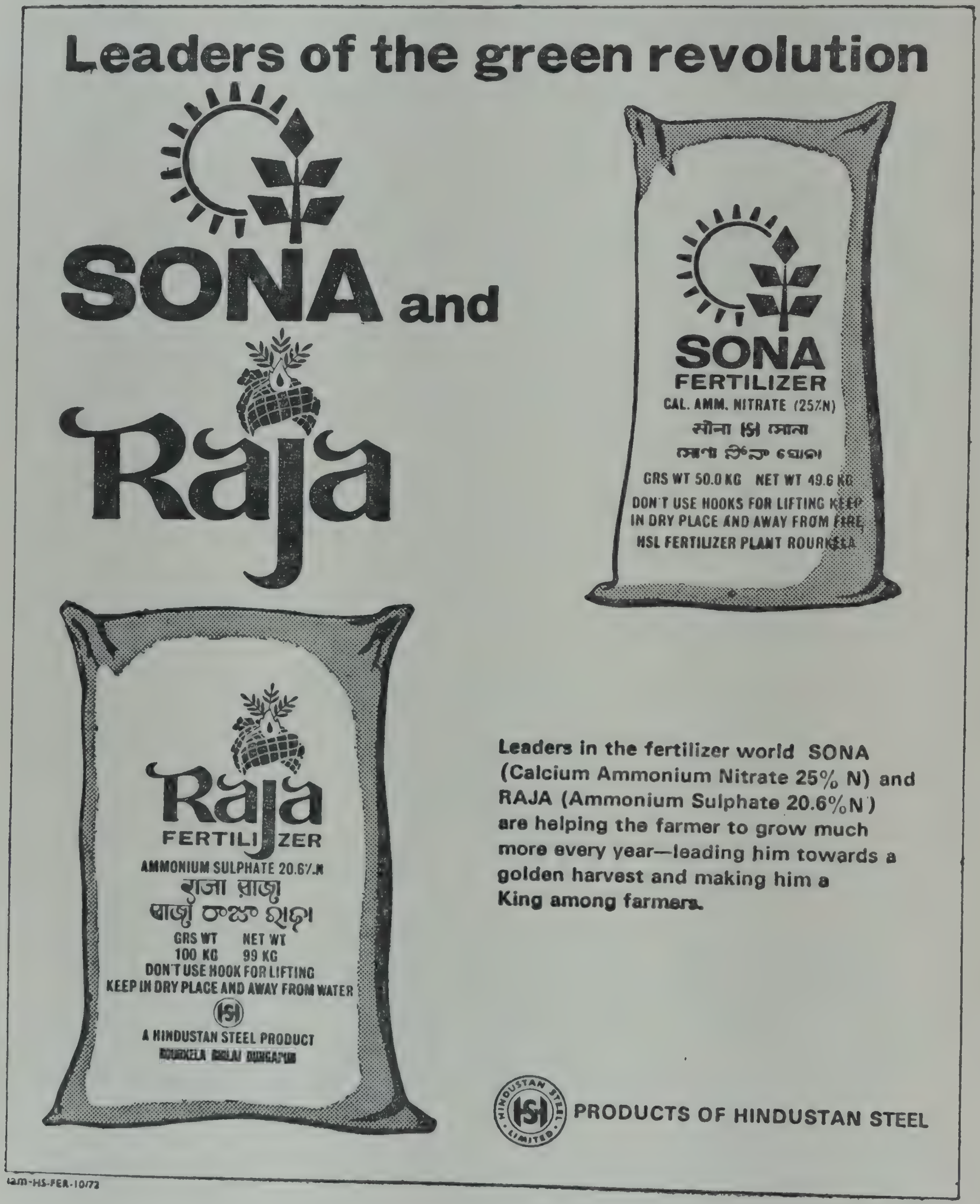
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Editor's page

The Poverty Belt

IN the twenty-fifth year of Independence, we want to point out a colossal fact of Indian life—the poverty belt in India. That it remains so is unfair. By and large it is in this belt that those under-privileged brethren of ours live—200 million below the poverty line.

In our last issue, there was a sombre sentence in the contribution from the Dry Farming Project Co-ordinator's cell: 'A shadow of despondency looms large and wide over vast tracts of our good arable lands in as many as 84 districts of the Union.' Why? Because, even today they look to the skies with uplifted hands for that scanty precipitation, which even in three years out of four, play cruel jokes on them. And this belt runs through the heartland of India.

But then, breastbeating is not the answer.

Of course we have launched our dry farming programmes. Are these enough? Let us be thoroughly objective. Somewhere in the deep recesses of our hearts we have a feeling that these are inadequate. A little improved barley here, a little improved summer rice there, a little tinkering with osmotic pressure, all these are not going to change the landscape of the poverty belt. What is envisaged is a titanic struggle in which plants, animals, soils, the elements and the man would be locked, from which phoenix-like a new land and a new action would arise. This is not just rhetoric. Some of the best scientific minds in the country are having self-critical prognostications on these lines.

Should all the best activists in the country converge on the poverty belt? Why not?

We have in our minds a programme for the resurgent youth. In some of our deeply reflective moods, we feel the youth of India, particularly the student community, has never been more healthy as they are today. We should have been alarmed if they were in a state of semi-coma. No one would say they are so today. For every five hectares of dry land, let there be a young man in charge—all agricultural graduates, all Ph. D.s, all M. Sc.s, all B. Sc.s. If they are not enough, let all the students undergoing these courses also converge on the dry belt. For five years let them be there. Let them get their degrees also—a new edition of the *Tamra Patra* for post-freedom struggle. Let them change the face of the poverty belt. Let them end poverty in India.

For this let a call be given by the Prime Minister—the great contemporary figure of credibility—and the scientists of India. They will rally.

They should feel employed also. This should not be a volunteer job in the *Seva Dal* sense. For this a new financial and economic theory would have to be evolved. The economic and financial experts cannot look for precedents. There are not any. They will have to burn all their 50-year old books. They will have to evolve theories and practices out of the realities of the Indian situation. That would be the new economic theory for developing India. Yes, for a new action programme.

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SCIENCE AND DESERT CONTROL

H. S. MANN

Director, Central Arid Zone Research Institute, Jodhpur

THE Indian desert occupies over 3.2 lakh square kilometres of hot desert located in Rajasthan, Haryana, Gujarat besides small pockets in peninsular India. An area of about 70,000 square kilometres of cold desert in Ladakh in Jammu and Kashmir presents desertic conditions entirely different as compared to the hot desert.

The area under the desert in India is about 3½ times the combined area of the States of Punjab and Haryana. About 20 million persons live in desert which is about twice the population of Haryana. The population of the Indian desert is about 1 1/2 times the population of Australia. Besides the human population, the cattle population with desert is about 23 million. The problem of desert control becomes quite difficult because the technology evolved has to be introduced and implemented while the human and livestock population has not only to be sustained but improved. Besides its economic and social importance, the desert has direct and indirect influences for the entire country. Agricultural production and otherwise living standards in the rural areas located in the more favourable conditions of the country are increasing and has caused regional disparities and imbalances. The desert is, therefore, a national problem and it has been attracting attention of the Indian Parliament.

Established in 1959, the Central Arid Zone Research Institute at Jodhpur has conducted scientific studies to evolve technology not only to control but also to improve the desert.

For providing a solution to any problem, its causes must first be established.

Our researches have shown that Indian desert is 'Man Made' caused by man and his animals helped by climate. Attention has been given to the question and belief that the desert is marching. Available data, however, do not lend support to this belief. But there is evidence that there have been local changes in the volume of sand within the desert.

The major overall problem is the need for more water. However, to provide more water in required quantities and quality at reasonable cost is not simple. It is important to understand, besides the amount and quality, the sources of water to the desert, its variability and predictability. These aspects have received our attention and efforts and further research studies in those aspects are being intensified. The scarcity of water and vegetation, food, fodder and fuel leads to over-exploitation of the natural resources which consequently cause erosion leading to loss of soil and its fertility. Even when and where water becomes available the establishment of vegetation, afforestation and plant yields are poor. Scarcity condition leads to nomadism and misuse of the land. Problems of employment and under-employment arise.

Water Main Limiting Factor

Water is the main limiting factor for agricultural production in arid zone. Therefore, investigations on how the limited water received as rainfall gets dispersed is very important. Methods have been evolved by the Institute for predicting fairly accurately the soil moisture under the native grasses from climatological parameters. Efforts are being made to develop such evapotranspiration models for cropped areas also. A rapid field method for determination *in situ* of hydraulic conductivity of sandy soils which determines the rate at which the water would penetrate into soil has been evolved.

Surveys have located areas where new *Nadis* or reservoirs could be constructed for storage of runoff from rain water. In many areas in Western Rajasthan in absence of suitable ground water aquifer, this is the only source of water for drinking, stock use and for other domestic purpose. Since the infiltration rate is very high in sandy tracts, the runoff is hardly 5 per cent of the rainfall. Detailed work on suitable treatments and prevention of loss of water through evaporation and seepage is in progress.

Since surface water is quite limited in arid regions, the alternative source for water is underground. The Institute has modern geophysical equipment (Seismic refrection and resistivity equipment) with the help of which detailed survey for underground water in different areas is being carried out. The survey can predict the depth at whch the aquifer is located, the water cushion, delimitation and aquifer, the approximate rate of discharge, source and rate of recharge and also the quality of water.

About 85 per cent well waters of Barmer, Jalore and Jodhpur districts are distributed in classes C_3, C_4 and C_5 which is normally used for irrigation of salt tolerant varieties of crops. About 10 per cent waters having T.S.S. over 10,000 P.P.M. are unsuitable for any use. Only 5 per cent waters are fresh waters. Boron content in ground water aquifers goes up to 7.5 ppm but majority of samples have values of 2.5 ppm or less and are suitable for irrigation.

The Institute has developed a technique by which it is possible to locate the sites of shallow underground water sources from an interpretation of the aerial photographs of buried dead drainage system.

Techniques for desert control include scientific management of water, soils, plants, animals and man himself. Technology on these various aspects has been evolved and is being perfected by our scientists.

It may, however, be emphasised that the technology of the desert control and its development is to be adopted

A view of landscape (drifting sand dune) in Jaisalmer district

A view of improved pasture at Jodhpur

by over 5 million farm families in an area of over 3.2 lakh square kilometres. Stated differently, about 12% of the geographical area and 11% of the human population is involved. The people in the desert, as elsewhere, are suspicious. They are not sure that the suggested measures are for their own good. It is difficult to convince them to give up age-old habits like unsystematic and uncontrolled grazing of cattle and sheep and cutting of grass and shrubs. This difficulty of the man and his habits is one of the chief bottlenecks in desert control. This is a major psychological and extension problem. It appears that, in general, economic and social researches basic to this problem are less advanced than those in natural sciences. This is particularly so in the desert area because of the characteristic social conditions, nomadic population, low literacy, poor living standard, lack of roads and other communications. The Institute has recently started research in extension. Field work in few selected villages has also been taken up.

Successful Demonstration

Based on the scientific work conducted, we have successfully demonstrated practices like afforestation, establishment and improvement of pastures and grasslands, shelter belts, wind breaks and sand dune stabilisation. Modern agricultural techniques evolved include contour bunding, sub-soiling, fallowing, strip cropping fertilizer use and water harvesting. Besides providing a vegetative protection cover, these techniques increase yields of food, fodder and fuel up to 300 per cent. Studies on the Geology, Hydrology and Geomorphology of the area and other agricultural disciplines have led to fuller understanding of the basic resources available.

Proper land use is important and it includes well-planned and systematic use of land according to its capability to give higher productions without deterioration. Integrated basic resources survey on broad reconnaissance basis have been completed in 45,267 sq km area and appropriate land use recommendations has been made. The areas surveyed cover part of the State of Rajasthan, Haryana, Gujarat and Mysore. In addition semi-detailed integrated surveys have been conducted at Development Block level in 11,197 sq km mostly in Western Rajasthan. Besides, the detailed survey at village level has also been done in 10,421 ha of land.

These integrated surveys provide details of climate, including analysis of commencement and length of agricultural growing season, occurrence of drought, type of different landform, types and characteristics of soils, their fertility status, land use capability classes showing suitability of land for agriculture, pasture development and forestry, sources and potentialities of ground water, their quality, surface water stream and their runoff and also the socio-economic conditions of the people of the area. Possibilities of exploitation of surface water and ground waters have been indicated.

In the State of Rajasthan, 19% of the arid land comprising Central Luni Basin and Bikaner district has been surveyed at reconnaissance level. 5.7% of the area comprising Siwana, Saila, Ahore, Jalore, Luni and Chohtan Panchayat Samiti blocks have been surveyed in semi-detail manner. In Haryana state 23% of the arid area, in the Mahendragarh district; in Gujarat state 2.2% of arid areas, in Santhalpur block; and in Mysore State 24% of arid area in Challakere taluk have been surveyed at reconnaissance level. Amelioration measures have been suggested for bringing these areas into production. Possibilities of exploitation of surface water and ground water in each block have been indicated. The quality of water in each block has also been assessed and recommendations made regarding its suitability for irrigation.

Atlas of Rajasthan with reference to agriculture has been printed. This atlas gives physical, agricultural and socio-economic conditions of different regions of the State. These maps also show problem areas

A view of silvicultural experiments plot

where immediate attention is needed to draw up reclamation and development programmes.

It is imperative that to control the desert a strip of land of about 10-15 kilometres width along the edge of the desert is brought under public control and measures for controlling the desert adopted and extended from this strip inwards towards around the desert in a phased manner.

Pasture and Grassland

Natural vegetation provides cover on the land against wind and water erosion. It improves the land. There is a need and scope for improvement of the existing pasture and grassland. A number of grass and legume species which are high yielding, quick growing and have higher nutritive value have been selected. At present hardly one sheep can be sustained on one hectare of land which can be increased to about 4 sheep per ha per year.

Another important technique to control the desert is afforestation including establishment of shelter belts and wind-breaks to provide mechanical obstacle to the free sweep of wind so as to reduce its velocity and deflect it upwards. Such obstacles besides reducing the wind velocity, thereby reduce the soil erosion as also the evaporation from the soil and minimise the desicating effect of the wind.

The present area under forest in desert is about 1.5% which is extremely low. There is a need and also a great scope for increasing forest areas in the desert. Out of the 250 and odd species introduced from a number of foreign countries a few tree species like *Acacia*, *Eucalypptus* and a few others have been identified. These new introductions are fast growing and provide more timber, fuel and fodder. We recommend that each farmer should have a wind-break of trees and shrubs in the south-west of his farm. Nursery techniques for raising tree seedlings have been evolved. Techniques for establishment of avenue plantings, shelter belt rehabilitation under various soils including hilly conditions have been worked out and standardised.

Livestock

Desert is well-known for its excellent breed of livestock. However, livestock population appears to be much higher in proportion to the existing available and exploited resources. There is a tendency on the part of farmers to overstock in favourable years and this is continued in unfavourable years which results in overgrazing and causes further damaged to the poor vegetation and to the exhausted soils. Once overgrazed, carrying capacity falls below normal which should be avoided. Our investigations have shown that desert can support several times the present number of livestock, if the recommended management practices are adopted. In area where higher production of livestock from half or less the number of animals has been demonstrated, it has not been found easy to convince the farmers to reduce the strength of their herd.

Research studies in physiological genetics of the six main breeds of sheep found in Rajasthan have shown that the low blood potassium type (LK) sheep adapted to the desertic conditions, have been found to have finer wool than the high potassium type (HK) animals. Since the blood potassium types are inherited characters and since the gene for high potassium type is homozygous while that for low potassium type is heterozygous, it has been thought possible to evolve through controlled mating, a homozygous low potassium type line within each breed by culling the high potassium type progeny at each generation. Work along these lines is in progress. A few LK males have been bred which are now being used for breeding desirable types.

Association between another biochemical polymorphic character, viz., haemoglobin type and production characteristics in sheep is also under investigation.

Studies have shown that Marwari breed of sheep can be given water every third day without any deleterious effect on animal health thus affording about 25% saving in water.

The rectal temperature has been found to be repeatable in the sheep. This finding is being used as a suitable index for the selection of animals suitable for the arid region.

Desert gerbil is a major pest in arid region, destroying crops, grasses and seedlings of trees. A method for control of gerbil evolved consists of using air-dried berries of *Zizyphus nummularia* (ber). These are soaked for 24 hours in a solution of sodium monofluroacetate (compound 1080) impregnating a 3 mg/kg dosage so as to make every ber lethal for one rodent. The lethal ber are mixed with unpoisoned ones in the proportion of 1 : 4 and placed inside the burrow openings. The poisoning cost varies from 0.5 to 1 paise per hectare. Besides, bait shyness, lethal dosages of various poisons for rodents, bait preference, food, breeding biology, population dynamics, home ranges and relative abundance in various desert districts have been extensively investigated.

As mentioned above, the nomadism under the existing conditions has been an unavoidable and necessary characteristic of the desert. The nomadic tribes population is approximately 2,50,000. Some of them are anti-social. Shifting human population alongwith its herd of cattle and flocks of sheep and goats has its undesirable social implications in addition to their cruelly exploiting natural resources. Our sociological studies have provided basis for settlement of nomadic population so that they take interest in the conservation of resources. Nomadic population so settled will be an asset to the area and will no more be a menace to the society.

High winds and insolation energy are another characteristic of the desert yet to be exploited. Attention is new being given to harness this energy for power generation for electricity, heat and lifting of water for domestic and agricultural purposes.

QUARTER CENTURY OF AGRONOMIC RESEARCH IN INDIA —A SURVEY

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It is appropriate that in the 25th year of our freedom we should take stock of our achievements and set new goals for coming years. In order to recapitulate the significant milestones traversed during the period the achievements on three dates could be discussed.

Agronomic Knowledge as it Existed in 1947

This information has been ably summarised by Burns in the note entitled "Technological Possibilities of Agricultural Development in India, 1944." The note formed the basis of the "All India Policy for Post-War Agriculture." It reviewed the area, yield trends during 1911-1943 and the prevalent agronomic technology to raise the yield in subsequent period. In the chapter "The Shape of Things to Come", he pleaded for the abolition of poverty of the cultivators and the abolition of the poverty of the soil. To achieve these twin objectives he referred to the need for cutting out various kinds of waste which existed such as waste of fertilizer material, water, soil, etc., and utilizing these factors to the maximum capacity. Dealing with agronomy, he observed that "finding from the results of 5000 experiments in India it is probable in most parts that soil has become stabilized at a comparatively low level." The low productivity of the inputs was construed as low productivity of the soil—a fact which came to surface when high-yielding seeds were introduced in mid-sixties. Agronomic research did not make an appropriate impact on production because agronomic thinking was circumscribed by traditional plant types and agriculture.

Agronomic Knowledge Before the Advent of the High-Yielding Varieties

Fortunately, V.G. Panse, T.P. Abraham and C.R. Leelavathi have summarised the information in their excellent publication "Yardsticks of Additional Production of Certain Food Grains, Commercial and Oilseed Crops, 1964". In this bulletin results of field experiments on food crops, pulses, oilseeds and commercial crops with respect to their response to fertilizers, green manure, farmyard manure, compost, irrigation, cultural methods and soil conservation methods have been summarized statewise. Each yardstick has been based on thousands of field experiments conducted by Central Institutes, State Department of Agriculture and Fertilizer Experiments were conducted even at farmers' fields. Developments in post-independence era such as the initiation of the irrigation projects, fertilizer factories, Intensive Agricultural District Programme provided the stimulus for a radical reorientation of research policies and goals. To the closed agriculture which depended on soils, air, water and the labour, the farmer and his family purchased inputs like fertilizers, weedicides and other agricultural chemicals. Research efforts in newly opened Central Research Institutes and State Departments of Agriculture produced data on the response of these crops to fertilizers, irrigation, culture practices and weed control. The gains as a result of the application of these inputs were substantial over the national average but they were not so great as to be called "breakthrough."

Advent of High-Yielding Varieties and Intensive Cropping Programme

Advent of high-yielding varieties and intensive cropping programme opened new vistas in yield in the year 1965. Consequently, a new stress was put on agronomic thinking. The new yield possibility and soil and crop management levels required by these varieties precipitated a re-assessment of our old agronomic concepts and ideas. The time span of our experience is so short but personal involvement of the author in training the departmental officers and farmers during 1965-68 provided him an opportunity to see the unfolding of this drama. The askance on the face of the trainees noticed by us indicated that they have to unlearn several age-old concepts and learn quite a few things.

Earlier agronomic experiments used to be designed to provide rationale to the current practices followed by farmers in a locality. Agronomists were trying to seek answer to questions within the concepts developed over centuries of experience and a few decades of experimentation.

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efficient techniques of performing different activities at the farm are now being perfected. This has been made possible only by questioning age-old concepts of crop production. Agronomists are, in post-HVP era, asking questions pertaining to "Whys" of different practices followed by farmers. When these "Whys" are understood unconventional methods of performing the job on the farm are worked out. The results of this type of investigation have been spectacular. Age old theories and concepts are crumbling and a new agronomic technology is emerging. The 'plant types' in most crops have been changed and 'ideal types' have been/are being developed in several others. The technique of a breeder is now 'model building' and not the 'defect elimination' as it used to be in the past. New crops, new varieties of old crops, and growing of crops outside their traditional season, very intensive cropping systems and minimum tillage are the frontiers on which agronomists are currently waging wars with numerous chemicals and machines which are readily provided by the industrial technology. The development path of new cropping system has been through relay planting, inter-planting, inter-cropping and multiple cropping. As a matter of fact, agricultural innovations during the last decade have increased so rapidly that the gap between actual and optimum output is usually high and particularly so in irrigation farming. The main weaknesses of irrigation system are not inherent in the system as such. Rather they lie in the inadequacy of water control, husbandry practices and irrigation institutions. This weakness has delayed a rice revolution in India.

Some modern agronomic concepts emerging as a result of experiments are given below.

Minimum and No Tillage Concept

The necessity to restrict the establishment of undesirable plants gave rise to tillage in the early days of crop production. Through the ages that followed, tillage and more tillage became accepted as a requirement for successful production of most food crops. The belief gradually developed that tillage was not only necessary under existing conditions to prevent or reduce competition for moisture, nutrients or light but to produce or maintain favourable soil conditions for crop growth. Developments in tillage research in fifties have brought about revolutionary changes in our ideas of tillage requirements. With the advent of herbicides the need for tillage to control weeds in certain crops no longer existed. This, together with economic pressure to reduce production cost or save time in multiple cropping brought about a critical examination of the function of various tillage practices that have been accepted as essential. In recent years in the form of 1, 1-dimethy 1-4, -4 dipyridylium (Paraquat) we have a rapid killing chemical, combined with the absence of a residual effect. This permits a more rapid establishment of the desired species without or with minimum tillage. The adaptability of no-tillage to a given situation may be dependent on the availability of suitable herbicide and machinery. Our researches have shown that maize and wheat could be grown with no tillage techniques.

Changes in Concepts of Crop Rotations, Green Manuring and Organic Manures

Gradually agronomists, soil scientists and practical agriculturists who used to swear by crop rotation are thinking of intensive cereals cropping. Experimental evidence on the effect of intensive cropping of cereals has accumulated. The results could be summed up in a new philosophy in land use enunciated first by Melsted (1954). It is a philosophy of maximum crop production per acre of land with a minimum of soil deterioration. The philosophy is based on the concept that high production is good for soil, that minimum tillage promotes soil tilth and conserves soil organic matter, that high fertility promotes high yields and lessens the losses of soil humus, that large amount of decomposable organic matter in soil is essential to good soil tilth and good soil physical conditions and that cover in the form of living mulch is good protection against all forms of erosion. Researches done in our country have shown that green manuring is neither the most profitable practice nor is capable of increasing the organic matter content of soil in which wheat and sugarcane are grown in northern India. Long term data from Pusa (1908-63) have shown that purely inorganic but balanced fertilization of crops is conducive to higher yields and maintenance of soil fertility. Green manuring does not seem to have much value in raising the organic matter content of soil to a high level in subtropical climate. Long term experiments have shown that besides its nutrient effect, organic manures do not have much of cumulative effect. We have learnt the technique of producing organic matter with inorganic fertilizers.

Change in Cropping Pattern with Respect to Summer Pulse

Kharif pulses have been an item of cropping schedule with very little contribution to the earning of the farmers because of low yields. They have hardly been able to stand the competition with high-yielding varieties and hybrids of cereals grown in this season. From the overall productivity point of view of the land per unit time, it is necessary, therefore, that the kharif season pulses be replaced by better suited crops. However, the pulses constitute an important item of daily dietary requirement of Indian masses, hence it is necessary that they should be provided with alternative position in the cropping sequence of the tracts where kharif performance is poor. For the areas of assured irrigation, there is good scope to take the kharif pulses in the rabi, zaid, between the period from April to early June.

Multiple Cropping

The philosophical implications of the changes on the role of cropping system, green manuring, no tillage and heavy fertilizer use have now started penetrating into the realm of soil science. We have now learnt that soil is receiving the best care when it is producing maximum yield within the limit settled by the climate, location and agronomic technology. As a result of the availability of shorter duration varieties of cereals multiple cropping has become feasible and commendable rotations involving 3 to 4 crops per year are being evolved, perfected and popularized on the land where farmer has sufficient water at his will. The soil management problems presented by multiple cropping are complex and for their solution integrated research done by plant breeders, plant pathologists, soil scientists, meteorological physicists and agricultural engineers is needed. It is becoming increasingly clear that six main types of factors limit the possible occurrence and importance of different types of cropping in actual farm situation. Within the framework of successive limitations of this kind, development paths are being perfected for multiple cropping in major farming situations.

Farming System Approach

It has become increasingly clear in recent years that ecological, economic and socio-institutional factors of agricultural production affect the farming system. In the process of adopting cropping pattern and farming practices to the conditions of each location, more or less distinct types of farm organisations have developed. They have their distinct problems of soil fertility, cropping with risk and uncertainty, low labour productivity and problems of seasonality. Agronomic research has taken cognizance of each of them and is trying to fit pattern of performances to suit them. The farming systems are: shifting cultivation system, semi-permanent cultivation systems, systems with permanent cultivation on rainfed land, systems with arable irrigation farming systems with perennial crops and grazing systems. Our institutes and coordinated projects are analysing the components of these systems and perfecting techniques which when applied in a package approach will give increased overall productivity consistent with sustained yield over long periods.

Experimental Designs

Earlier agronomic experiments were mainly centred round the comparison of varieties, fertilizer application, time and rate of seeding, etc. Concepts of a potential yield determined by weather (uncontrollable part of the crop environment) technology (controllable part of the crops environment) and management (the precision with which the technology is applied) was generally unrecognised. The experimental designs used by the agronomist did not allow a measure of the variability that might be expected from a wider application of the results. The coordinated schemes have taken these factors into consideration. The production potential experiment of model agronomic scheme is designed to find out the production under different agroclimatic regions. During the last two decades the following improvements have taken place in the methodology of the experimentation. This has enabled agronomists in generating more meaningful data.

(i) The experimental design have been expanded to estimate responses and the variability of responses over a region and over a range of seasonal conditions. This has made possible the (a) elimination transfer variables, (b) to define the 'population' for which the results will be valid e.g. for a crop trial stipulate the soil types, geographical area, topographical situations, climatic zones or other requisite parameters and so define the limits to some degree, the environmental variables, (c) to sample this population adequately by means of experiments which may be fertilizer trials, physiological experiments so as to obtain responses and an estimate of expected variability of the responses, (d) estimate of the variability of response from season to season. Designs are available which permit the assessment of the variability of responses in the field with space and time. They permit the calibration of the soil chemical test with responses and establishment of soil chemical criteria.

(ii) The examination, as a whole, of problems affecting a region or industry. The experimental approach to this means of variables and their inter-relationships could be to divide the problems into a number of, so far as possible, autonomous sections, select one or more variables and then endeavour to coordinate the results.

(iii) Whole farm studies of the effect of applying the new technology.

(iv) New concepts in the design and analysis of the agronomic experiments—analysis of variance while satisfactory for discrete data, is inadequate for the interpretation of data that measure a continuous response. In dealigning experiments that measure a continuous response the present day tendency is towards regression analysis frequently with an increase in the number of treatments at the expense of replications.

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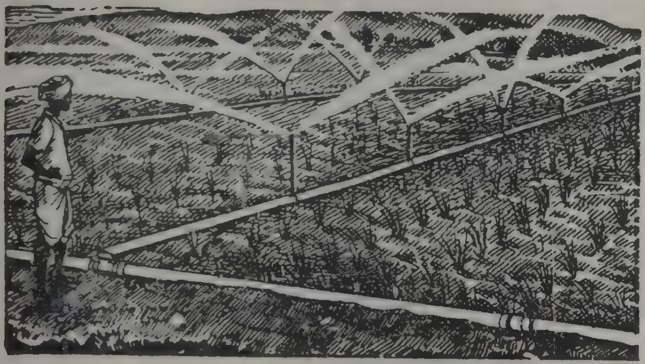

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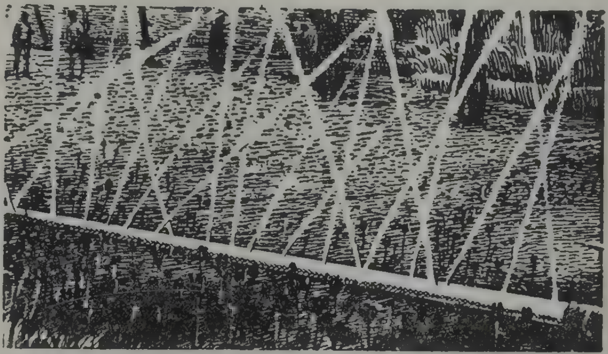

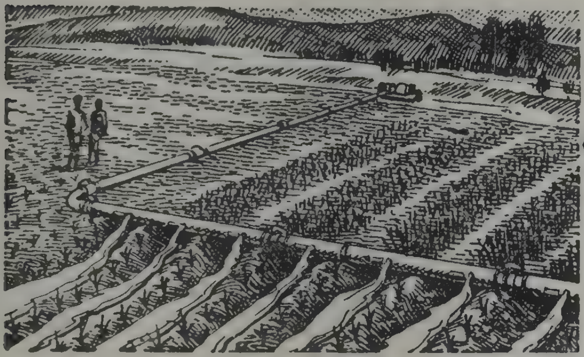

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TWENTY-FIVE YEARS OF RESEARCH ON FRUIT CROPS

S. L. KATYAL

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A QUESTION generally is asked by scientists and general public as to what we have achieved in fruit crops research during the last quarter of a century and in what way the research investigations carried out so far have helped the fruit growers of the country.

In order to understand the gigantic task which the research workers have to fulfil, it will be better to trace the history of fruit cultivation in India and to highlight some of the salient features of fruit crops in the country.

It is indeed a remarkable gift of nature that on account of diverse geographical and agroclimatic conditions existing in various parts of the country, any fruit which can grow anywhere in the world can find a place in India too. The climate ranges from typical tropics in Kerala to extreme temperate in the high hills in Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh. We have areas in Mehghalaya which get the highest rainfall in the world and areas in Rajasthan and Andhra Pradesh, get very little rain. It is no wonder then that we can produce a wide range of fruits, tropical, sub-tropical and temperate, the annual production of which is estimated at seven million tonnes from an area of 1·25 million hectares.

Many of the fruits like banana, mango, citrus, etc. are indigenous to India, while others have been introduced into the country from abroad.

However, organised research in fruit crops, began with the setting up of the Indian (then Imperial) Council of Agricultural Research in 1929, when funds were made available to the State Governments for ad-hoc research on these crops. Till then, some work on fruit crops was carried out by a few States like Bihar, Bombay, Madras, Uttar Pradesh and the Punjab. Some outstanding fruit researches like on mango bearing behaviour by Burns in Bombay and on citrus rootstocks by Brown in erstwhile North West Frontier Province, are quoted even now. The Indian Council of Agricultural Research sponsored many fruit research schemes and in the year 1954 it strengthened the researches by setting up a few regional centres and some coordinated schemes like citrus die-back, the use of growth regulators, etc.

No provision was made in the First Five-Year Plan for work on fruit crops. During the Second Five-Year Plan, some work was initiated with the setting up of a small Division of Horticulture at Indian Agricultural Research Institute, which led to significant impact by the initiation of improvement projects in fruits and vegetables.

Great landmark in the country in Agricultural Research came with the re-organisation of the Indian Council of Agricultural Research in the year 1965, when several individual commodity committees for coconut, arecanut and cashewnut were abolished and their research functions were taken over by the ICAR. Many of the Institutes which were under the Ministry of Agriculture like Central Potato Research Institute, Simla, came under the purview of the ICAR. The extension of this activity led to the establishment of the Indian Institute of Horticultural Research in the year 1968 at Hessaraghatta (Mysore State).

During the Fourth Five-Year Plan, All India Coordinated Fruits Improvement Project was launched on a national basis to tackle different problems facing the industry in a multi-disciplinary way. The Project has besides the coordinating centres at IARI, New Delhi, and Indian Institute of Horticultural Research, Hessaraghatta, 17 centres to tackle the problems of 8 important fruits growing in the tropical and subtropical regions and different temperate fruits growig in the hilly regions. This project has been sanctioned at a cost of Rs. 56·3 lakhs for the Fourth Five-Year Plan period. In addition to this many *ad hoc* research schemes on 100% basis are being financed by the ICAR in different ICAR institutes, Agricultural Universties and other centres in the States.

In will not be possible to give a full account of the achievements in fruit research in a small article like this but mention will be made in the following paragraphs of the important work done on different fruits.

Mango

Being the most important fruit in the country covering almost 50% of the area in fruits and its appeal to the masses, the mango drew the attention of various horticulturists in the country long back. In early 30's the Council intensified research work on mango at Krishna Nagar (West Bengal), Sabour (Bihar), Kodar (Andhra Pradesh) and Kanya Kumari (Tamil Nadu). Some of the outstanding achievements in mango are the determination of the suitable variety, the optimum propagation practices for each of the important regions of the country, standardized descriptions of important varieties-the breeding of a few valuable hybrids in Bihar and Madras, optimum methods of top working in Madhya Pradesh and Bombay. Recently, propagation by veneer grafting and seed grafting has also been perfected. Cold storage studies have determined the optimum storage life and storage conditions under which it can stay for long, in many varieties of mangoes. Some satisfactory control measures in dealing with several pests of mango like "Mango Hopper" have also been worked out. Intensive breeding work on mango has been carried out at IARI recently and many crosses have been made with combinations involving regular bearing varieties, Neelum, Totapuri Red Small and Bangalora with the most popular but irregular varieties of North India, like Dusheri, Langra and Chausa. Some promising hybrids like Malika have been evolved and further work is in progress.

Many of the problems of mango industry are of a long term nature like alternate or irregular bearing, manurial requirements, suitable root-stocks, mango malformation malady, etc. The recent thinking is to evolve dwarf root-stocks so that more number of trees can be accommodated in per unit area with early maturing varieties which are regular bearers and have a demand in foreign markets and also are fit for the preservation industry.

Banana

During the last one or two decades, lot of attention has been paid by the research workers to banana cultivation. As it is a potential source of foreign exchange earner when exported to U.S.S.R., European countries, Persian Gulf and Japan, its importance has now been increasingly felt. Cultivation and agronomic practices have been standardised in many states and a number of areas have been identified for growing bananas for internal consumption and for export.

At present, the Indian Institute of Horticultural Research is engaged in the improvement of banana through selection, hybridization, and mutation breeding. Early research work in the country on banana was confined to selection of varieties from indigenous and exotic sources, methods of propagation, use of plant growth regulators for regulation of fruiting, experiments on fertilization and control of diseases. Besides, Basrai Dwarf, which is an important variety for internal consumption as well as for export purposes, 'Robusta', the semi-tall mutant of Dwarf Cavendish has been isolated by the Banana Research Station, Aduthurai for cultivation in differet parts of the country. This variety has all the attributes of an ideal export banana. At Agricultural College, Coimbatore, varieties such as Bimkele, Attaikol, Red Banana and Poovan have been found to be resistant to wilt.

Citrus

Citrus fruits are grown commercially in many of the states of the country and the work so far done in these fruits relates to descriptions of many of the cultivated and indigenous varieties, studies of nurseries techniques, root-stock and manurial trials carried out in Punjab, Madras and Assam and work on control of different pests and diseases. The citrus-decline is a problem facing the country in different regions and the ICAR has initiated schemes to tackle this problem in Coorg, (Mysore State) and Shrirampur, (Maharashtra State) right from the early 40's. Lot of research work has also been carried out at IARI, New Delhi, on citrus-decline. Some results like deficiency of micronutrients in Mysore State, greening and tristiza virus along with zinc deficiency in North Indian States and again micro and macro nutrient deficiencies in Eastern sectors of the country have been found. The ICAR has also initiated several projects on citrus bud wood certification besides the work being carried out under All-India Coordinated Fruits Improvement Projects in which citrus finds an important place. In order to tackle this problem effectively, a revised scheme on Citrus Decline has been formulated so that this problem which has different factors responsible in different regions can be tackled effectively. Rangpur lime has been found to be the optimum root-stocks for Mosambi sweet orange while for Mandarin; Rangpur lime, Wittekar, Malta and several other root-stocks have been found to be suitable. In Punjab, *Karna Khatta (C. Karna)* has been found to be the most satisfactory root-stock for grapefruit and rough lemon and Nasnaran introduced from Sri Lanka has been found to be suitable rootstocks for sweet oranges.

Guava

This is considered to be the poor man's fruit and occupies an important position with regard to area, production and popularity amongst the people. It is adaptable to almost all the agro-climatic conditions. All the commercially grown cultivars of our country have been obtained as a result of selection from the introduced material amd some of them are considered to be the best guavas of the world. As a result of seedings, selections, 'Lucknow-49' cultivar was evolved at poona. Plant hybridization work was initiated at Sabour (Bihar) and Saharanpur early but could not be sustained. Lot of work on propagation studies has been accomplished so far in guava. A new problem namely, 'Guava Wilt' has become quite severe in Punjab, U.P., Haryana and Rajasthan and work to tackle it has been initiated.

Litchi

Litchi occupies small areas in Bihar and U.P. and its delicious juicy fruit is available in the market for only a short time in May and June. Lot of work has been done in this fruit on propagation studies. Many important varieties of Bihar are China, Purbi, Dehra Rose, Bedana and Desi. Recently, the work on dehydration and canning of litchis and preparation of litchi squash has gained lot of momentum.

Papaya

Work in papaya has been done in selecting suitable varieties and in preparation of papain. Coorg Honey Dew has been evolved at Horticultural Experiment Station, Chettali (Mysore) from the second generation seedlings of cultivar Honey Dew and gives Hermaphrodite female plants and has extremely good quality fruits with dwarf plants. Coimbatore I, is another variety which has been evolved at the Agricultural Research Station, Coimbatore. Work on evolving varieties resistant to leaf mosaic disease is progressing. Studies on different sex forms have been undertaken in papaya at Saharanpur.

Pineapple

Pineapple is grown mostly in Assam, Kerala, Tripura, West Bengal, Orissa and Mysore States. Some good varieties of pineapple have been standardised and work on plant growth regulators for regulation of flowering, control of weeds with chemical weedicides and control of mealy bugs has been taken up. The recent work at the I.I.H.R., Hessarghatta has shown that the plant density can be increased to 43,500 per hectare in the Variety Kew. Ethrel even at very low concentration of 125 ppm has been found to be successful in regulating fruit harvest. Lot of work on optimum time of planting, standardization of population density for each region, fertilizer requirements, mulching treatments, etc. has still to be undertaken for this crop. Some good varieties for processing purposes also need to be evolved.

Grape

Work on grape cultivation has been undertaken during the last two decades in the country. Recent interest dates back from the selection of improved types from open pollinated seedlings of Pandhari Sahebi in the early twenties by Dr. G. S. Cheema, who obained Cheema Sahebi (Selection 7) and Selection 94. Lot of work on selection of varieties of grapes has been done at IARI. During the last decade, many good varieties of grapes have been introduced from abroad. The area under grapes in the country has increased enormously and avenues like processing for wines or making of raisens have to be found besides use of grapes for table purposes. India has produced the highest yields of grapes per Unit area (21·5 metric tonnes per hectares) due to some prolific varieties like Anab-e-shahi and manurial schedules. Lot of work in grapes has been done on plant growth regulators for improving the berry size and quality of the grapes. Gibberellic acid has been recommended for increasing the berry size of Thompson Seedless or Pusa Seedless grapes by dipping the clusters at 100 ppm at full bloom stage and 50 ppm at berry shatter stage. A good deal of work has been done with regard to plant protection and fertilizer applications.

Temperate Fruits

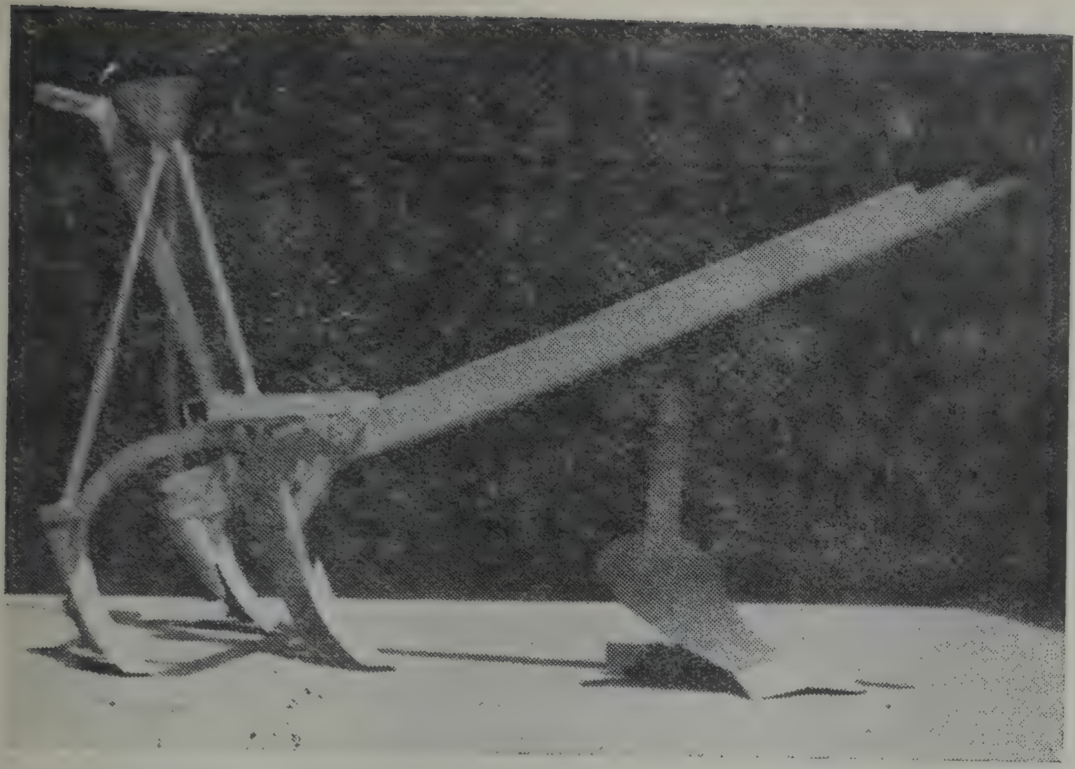
Apple is by far the most important fruit in this group which occupies about two-third of the total area under temperate fruits in India. The other temperate fruits include pear, peach, plums, apricots and cherries. The Fruit Research Station, Chaubattia, in U.P. has played an important role in the extension of horticultural activity in hilly regions of U.P. Similarly, Fruit Research Station at Mashobra (U.P.) has done considerable work on different temperate fruits. The area under apples and other temperate fruits has increased manifold in states of Himachal Pradesh and U.P. The rootstocks in apples have been standardized and propagation studies have also helped in improving the cultivation of the temperate fruits. Studies on different varieties of pears, plums, peaches, apricots has been taken up in different states.

Walnut is an important crop which has received some attention during the last one decade. Some good plant material has been introduced and studies on propagation are being carried out. Similarly, work on almond, chestnut, hazelnut, is under progress in different research stations.

Identification of Problems

There is now fierce competition between horticultural crops and high-yielding varieties of food crops. As compared to fruit crops which take a longer time to come into maturity, the cereals bring early returns to the farmers and as such his attention is diverted to cultivation of cereal crops as compared to fruit crops. The investment required in establishing an orchard is much more and there is no concession given by the Government on land ceilings. In order to supply the much needed nutritious fruit crops to the country, it will be desirable that these crops should not be brought under the land ceilings, and all the other facilities like irrigation water, etc. are made available for their cultivation.

As regards research problems facing these crops, mention may be made of mango malformation, citrus decline, guava wilt, bunchy top of bananas, papaya mosaic, etc. Effort has to be made to breed dwarf and early bearing varieties so that more number of trees can be accommodated per unit area and the grower gets the benefit earlier. The manuring of fruit trees is done on empirical formula. Work on leaf analysis is to be undertaken to know the requirements of the fruit trees. The export trade has set some standards and it is essential that cultivation of fruits is kept to meet these standards. The processing industry has also its special needs, such as seedless mandarin or a cylindrical pineapple and a breeding programme to evolve such types will have to be undertaken. A dynamic programme in evolving varieties of fruits that are not only high-yielding but are resistant to pests and diseases has to be introduced.



A mould board plough — 3-tyne cultivator with a seeding box

FARM MACHINERY FOR NEW AGRICULTURE

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THE first basic need for good crop growth is a good seed-bed having adequate depth from weeds for good germination and root development. This operation is being done with the wooden wedge plough, by a series of repetitive operations. Lack of penetration, narrow working width are some of the deficiencies of this tool, resulting in poor quality of work and low turnover. Early research (1930-45) workers therefore concentrated in the design of primary and secondary tillage implements both for dryland and wetland cultivation. Moldboard ploughs have been designed to suit different soil conditions and type of animals available in different regions. The important secondary tillage implements developed are blade harrow, disc harrow, triangular harrow, cultivators with a seeding bowl and the expanding cultivator for dry cultivation and the wetland puddler and the green manure trampler for paddy cultivation. A good combination of these implements can complete an area in one-third of the time and cost incurred with the country plough. There is therefore greater scope for achieving timeliness in operation which is necessary to raise yield. Another distinct advantage is the enormous reduction in the stress and strain on the man and animals involved in walking long distances during ploughing and the man gets more time to attend to the crops.

Special soil working implements namely, the ridge plough for planting sugarcane or potatoes, the bund-former for forming bunds on fields and the basin-lister for forming basins prior to rain for retaining rain water are the other useful contributions for the dryland farmer.

Some of the recent additions to this category of equipment are the Singh Patela, the knife harrow and the land leveller. A simple tractor drawn land planer has also been developed at IARI. The above implements make it possible for the small farmer depending on bullock power to go in for multiple cropping where the limited time available between the crops calls for the use of faster working implements having greater outturn. In irrigated agriculture, some of these, because of their ability to give a good level seed-bed aid uniform distribution of water resulting in better crop growth and increased production.

Most of these implements have become popular and a large number of small scale industries in almost every state are producing them.

Sowing

The normal practice is to broadcast the seed and fertilizer on the field and later on subject the plants to thinning. There is considerable wastage of both seed and fertilizer. Recent agronomic researches indicate that placing the seed precisely at any desired position in relation to fertilizer bands have given increased yields and drilling in rows also greatly help weed control. To achieve this precision operation research engineers have worked during the last decade, in the development of seed-drills and seed-cum-fertilizer drills which can place the fertilizer below the seed at any predetermined position. Single row manually operated machines have been designed at IARI, a two row paddy drill at CRRI and a number of multi-row machines for bullock power have been developed in Agricultural Universities and Central and State Research Centres, and also by manufacturers. Machines having 9-12 rows for tractors are also being produced in India and are becoming popular. Single shoe type furrow openers for both seed and fertilizer in place of double openers is a recent improvement which if perfected can double the machine capacity.

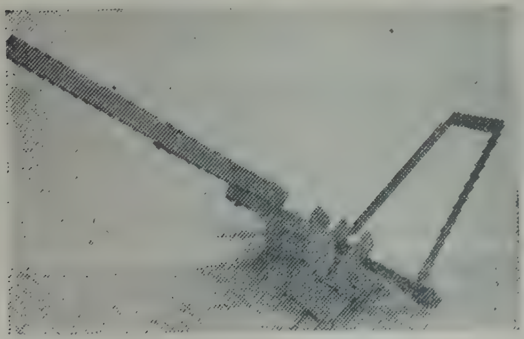
Indian Institute of Sugarcane Research have brought out machines for planting and fertilizing sugarcane at the same time for animal power and another for tractors is nearing completion. Work on machines for potatoes is also in advance stage of development.

The success achieved in Japan in the matter of development of paddy transplanters have also inspired a few young designers in India who have been actively engaged in the development of such machines for the past few years. A manually operated ten-row paddy planter designed by Mahapatra in Bhuvaneshwar has very promising design features and with more trials under different soil conditions, it can become a large scale commercial proposition.

The ICAR prize-award scheme for design and development of this category of equipment has paved the way for a very large number of new designs in a short period. But more requires to be done by way of qualitative improvement of the product and also improving selected ones as multi-crop machines. All these would be possible by a large scale evaluation programme of selected machines.

Water-lifting

Another very strenuous farm operation is lifting of water from wells through indigenous waterlifts, which had very low output. Researchers in pre-independence years paid attention to improve the efficiency of the indigenous waterlifts. The Persian wheel was improved by provision of machined gears, lubricated bearings and well-designed buckets. The South-Arcot mhote was improved by providing roll-easy mhote wheels, automatic tilting buckets. At Allahabad, a triple ram plunger pump for bullock power had been developed and was in use.



Wetland puddler for paddy cultivation

Tractor-drawn potato digger

The post-independence period brought in significant degree of mechanisation in this regard. Power pumps and diesel driven pumpsets were tested and introduced and their number has been rapidly rising from Plan to Plan.

Several implements—ridgers, buck scrapers, levellers, floats have been very useful to increase the water-distribution efficiency. Field research on the most efficient methods of preparation and distribution require to be intensified for different soils.

Chemical Application. Another impressive development in post-independence period is the design, development of sprayers and dusters. Application of chemicals to protect the crops not only was hazardous but also was ineffective as very small quantities of chemicals had to be distributed over a large area. There was considerable wastage of chemicals. Hence different types of dusters and sprayers—manually operated and power-driven have been developed and gone into large scale production. A combination of bullock power for haulage and engine power for boomspraying mechanism will have tremendous future for getting higher coverages even at later stages of crop growth. Implements for treating seeds effectively with chemicals have also been evolved. Designs of fertilizer distributor have been initiated for bullock-power in recent years and further work is called for in this direction.

As ammonia contains the highest percentage of nitrogen and is the cheapest source, studies have been initiated for design of back-mounted and bullock-drawn applicators at Poona, Kharagpur, etc. Though the basic designs have been developed, design of regulators and calibrations for varying outputs require to be perfected.

Harvesting

Notable success have been recorded at Ludhiana in the design and development of reapers for wheat, with indigenous material. A bullock drawn reaper was first developed which was improved by fitting a small 2 HP petrol engine for operating the cutting mechanism. Another similar design has also come out at IARI. In view of the large number of tractors operating in the State, tractor operated reapers-self-raking type and front mounted types have been developed at Ludhiana.

Design of machines for harvesting root crops—potatoes and groundnut using tractors also has recorded satisfactory progress at Ludhiana. Simpler designs for bullock-power have been developed at Coimbatore.

The machines have been developed as single crop machines and hence future line of research should aim at making them multi-crop units and in improving quality. With the incoming of different types of reapers and also threshing machines, time is now ripe for linking up suitable ones into combine harvesting and study in this regard have to be initiated.

Threshing

The age-long practice of threshing by animal treading, came to be improved in the last two decades by development of a simple implement called the Olpad wheat thresher having an output of about 75 kg per hour. This machine consisted of three rows of serrated discs mounted in the frame work. By drawing this with a pair of animals, threshing and bhusa making were achieved. Tractors are also being used to run over the layer of the crop to effect threshing. For paddy, the manual-pedal-operated thresher had been imported and tried out in several parts of the country in the fifties. These gave only about 75 kg per hour and proved useful only for hills and other areas where labour and animals were difficult to get. A 25 HP power driven wheat thresher having an output of about 6 quintals per hour had been developed in Punjab and has been getting popular on tractorised farms. In Patna the pedal thresher was improved further by giving it a speed-step up gear box for working by means of a pair of bullocks.

With the rapidly increasing numbers of low H.P. engines and electric motors 3 H.P.—10 H.P. for pumping, the need for development of other categories of stationary machinery to utilize this new farm power was increasingly felt. This gave impetus to the development of power threshers and winnowing machines suitable for the low power engines, in the last few years. Initial trials were carried out with some imported makes from Japan at some selected Research Centres in the country and development work was intensified.

Rapid developments came about with the ICAR announcing a prize award competition for low H.P. thresher. Several designers took interest in the competitions and many new designs have come into being. An analysis of the specifications of these machines made by the ICAR show that the power-grain output ratio varies widely from machine to machine. Constant efforts are needed to improve this ratio. Many of these have been designed as single crop machines. For multi-crop rotations, they have to be modified. Future research should aim at these aspects. Need for high output threshers and development of small power combines also exist in multi-crop systems.

Processing Machines

Some of the achievements in the pre-independence period were the design and introduction of sugarcane crushers and the chaff cutters which have made much headway in Indian agriculture.

In recent years, attention has been paid to design of shellers for maize, paddy, groundnut, castor, etc. Grading machines for fruits and groundnuts have been developed. Heat treatment for sugarcane has been studied at I.I.S.R., Lucknow. Machine for separating fibre from jute and ramie is nearing completion at Barrackpore.

A number of useful machines have come out at different centres. Efforts are needed for their evaluation at several selected centres and to popularise them.

Intensive agriculture needs more power and testing of different type of tractors was undertaken and good ones have gone for production. The demand for tractors has been going up and steps are afoot for raising indigenous manufacture to keep pace with demand to meet the needs of bigger farms. Similarly, for the small farms particularly for rice-cultivation power tillers would be of great use. A large number of power tillers have been imported into the country for studies and several makes—Akitu, Yanmar, Mitsubishi, Satoh, Kubota, Hako, Agria have undergone studies at Tractor Training Centres and a few other research centres. A few machines—Kubota, Krishi and Mitsubishi have gone for indigenous production. With this new source of power available, research would now be appropriate in the development of various categories operational of equipment discussed in preceding paras to suit them and to make these machines more economical to the small farmers.

An attempt has been made to indicate the future lines of actions with reference to the various categories of equipment. While the progress achieved can be considered to be satisfactory, there is great scope in improving the quality of machines, their durability, etc. The wide gap between research and manufacturer on one hand and the manufacturer and the farmer on the other has to be speedily filled up and this can be achieved only by a big programme of intensive prototype evaluations of those coming out of research Institutions. Effective standardisation of equipment designed will have to be planned.

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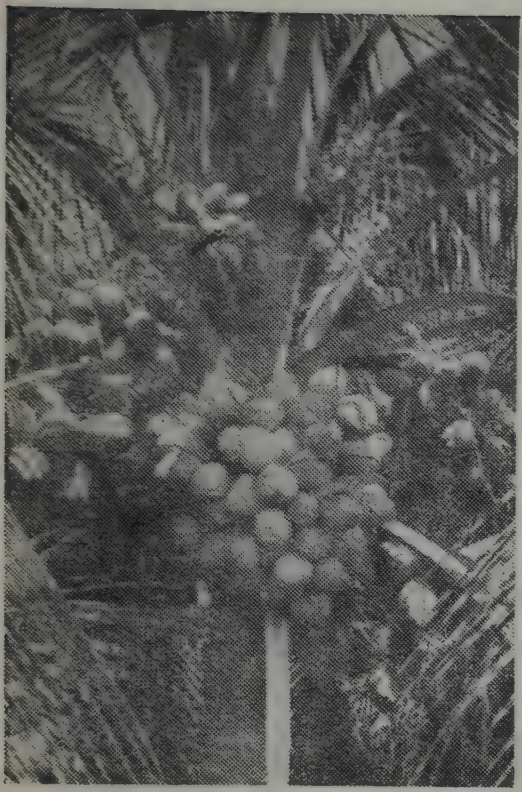

Hybrid coconut—gives better yield and is more disease tolerant

PLANTATION CROPS RESEARCH —A SURVEY

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PLANTATION crops which occupy about two per cent of the area cultivated under all crops in India account for an export earning of about 250 crores of rupees per annum. While production of crops such as tea, coffee, cashew, pepper and cardamom is highly export-oriented, coconut, arecanut, rubber, cacoa, oil palm, etc. are oriented towards import substitution and industry based. This article accounts in brief the salient achievements in the field of coconut and arecanut research during the last quarter of the century.

Arecanut

Large quantities of arecanut were being imported into India to meet the country's requirement. During the year 1956-'57, 39,903 tonnes of nuts valued at 5·45 crores of rupees were imported. Research on arecanut commenced from 1956 onwards had its impact on overall production as well as production per unit area as is evident from Table I.

The combined effect of improved agronomic practices and plant protection measures increased the per hectare production by 16% from the base year of 1956-'57.

Intensive work on the evolution of high-yielding varieties of arecanut taken up from 1960 onwards has yielded a new variety, 'Mangala' which is under release. This is precocious and semi-tall in habit having nuts of good market quality and pests and disease tolerance comparable with the local. It has recorded 71% more yield as compared to local, successively over a period of six years. This variety which is under release is expected to increase the per acre yield of arecanut substantially. A few other high-yielding varieties are also in different stages of field testing.

Coconut

In the evolution of high-yielding varieties of coconut, work done so far has shown that hybrids, involving West Coast Tall, Dwarf Orange, Gangabondam and Laccadive ordinary and the last variety by itself are superior to the local and can play vital role in enhancing the production of coconut in the country.

Of the above, the hybrids are not only high yielders, but are also early bearers which is an important characteristic in a crop like coconut which has a long pre-bearing age of 6 to 8 years. Reducing the pre-bearing age of coconut has far-reaching effects in stabilising the economy of coconut culivators. Research work taken up recently at the Central Plantation Crops Research Institute has indicated the possibility of bringing down the pre-bearing age of West Coast Tall variety of coconut to about two years. Further work is in progress on this aspect.

The coconut and arecanut planters are well aware of the superiority of these hybrids and varieties, but the extremely limited availability of planting material sets limits to their exploitation for production. At this Institute, programmes are now under way to produce superior hybrids and varieties of these crops in adequate numbers using modern methods of seed production.

Mixed Cropping and Farming

Root studies taken up in coconut have shown that in a unit area of the plantation 23 per cent of soil on area basis alone is being effectively utilised by the coconut roots. Seventy-four per cent of the roots do not extend beyond two metres from the base. On depth basis eighty per cent of the roots are confined to 31 cm to 120 cm layer of the soil. These indicate that the soil in a coconut plantation is in a position to support a number of other crops provided they are compatible.

The West Coast Tall variety which requires a manurial input of 0·5 kg nitrogen, 0·32 kg P_2O_5 and 1·2 kg K_2O per palm per year has been observed to produce a total of 12·67 tons dry matter (moisture free basis) per hectare annually. Of the different crop combinations of coconut and cacao, coconut, cacao and pineapple, and coconut, cacao, pineapple and pepper, the last combination can produce 19.3 tonnes of dry matter per hectare. The surface soil which is not being used by coconut plants offers favourable situation for raising grass and legumes for rearing milch animals. A project on mixed farming in progress at the Kayangulam Regional Station of this Institute gave an additional net profit of Rs 2,850 from a hectare of coconut garden during its initial year of operation. There was also a five per cent increase in the standing crop of coconut. The total dry matter production per hectare per year was 26·26 tonnes. With the substantial reduction in the cost of cultivation of coconut in this method of farming and the higher yield due to the improved management conditions, the net economy of this project will be much higher in due course.

Hybrids — More Disease Tolerant

Coconut and arecanut are prone to the attack of large number of pests and diseases. Of all the diseases, the root (wilt) disease of coconut which has spread over an area of about 2.5 lakh ha in central and south Kerala and causing an estimated loss of rupees 150 million per annum has shaken completely the economy of the small holders, who depend to a great extent on the income of their few coconut trees for their daily bread. The disease is of a complex nature and a rod shaped virus, a bacterium and fungi have been found to be associated with it. On the basis of preliminary indications about the field tolerance of one of the coconut hybrids to this disease, a survey was undertaken by the Institute towards the close of 1971 in Trivandrum, Quilon, Alleppey, Kottayam, Ernakulam and Idikki districts of Kerala State. The results are given in Table II

The data indicate that the D × T and the T × D hybrids are tolerant to the disease, the incidence ranging from 4.6 to 8.4 per cent as compared

For maximum return from the soil—mixed farming crop combination consisting of coconut, cocoa, pineapple and pepper

Raising grass for milch animals in coconut gardens

to 48.5 per cent in the common West Coast Tall variety. Another interesting observation is that the few D × T hybrids which are susceptible to the disease get infected mostly after the age of 15 years and therefore the reduction in yield is much less as compared to that of the West Coast Tall which is prone to the disease right from the beginning. It has also been observed that the decline of West Coast Tall palms affected in the early stages of bearing is much more rapid as compared to late infection. While the average yield of the diseased D × T palms is 46.4 nuts, the yield of West Coast Tall is strikingly low, only 9. It is interesting to record here that in Jamaica, more or less similar results have been obtained using Malayan Dwarf as one of the parents in the crossing programme against lethal yellowing.

Outlook for the morrow

In the wake of a concentrated multi-disciplinary research approach now being organised in the plantation crops destruction of barriers of production is expected to take place fast. Higher production and becoming self-sufficient in the requirement of each of the crop will have the accompanying problems of price structure coming down as has already happened in the case of arecanut. The stabilisation of plantation crop industry under such circumstances will depend upon how cheap the commodity is able to be produced so that even at lower prices the cultivator is able to make a reasonable margin of profit Development of post-harvest technology for the full utilisation of all the products involved in the crop including quality standards as required by the international market is essential so that the price of the commodity goes up Adequate market research should also be conducted to have first hand information on market trends,

Mangala—the new variety of arecanut under release

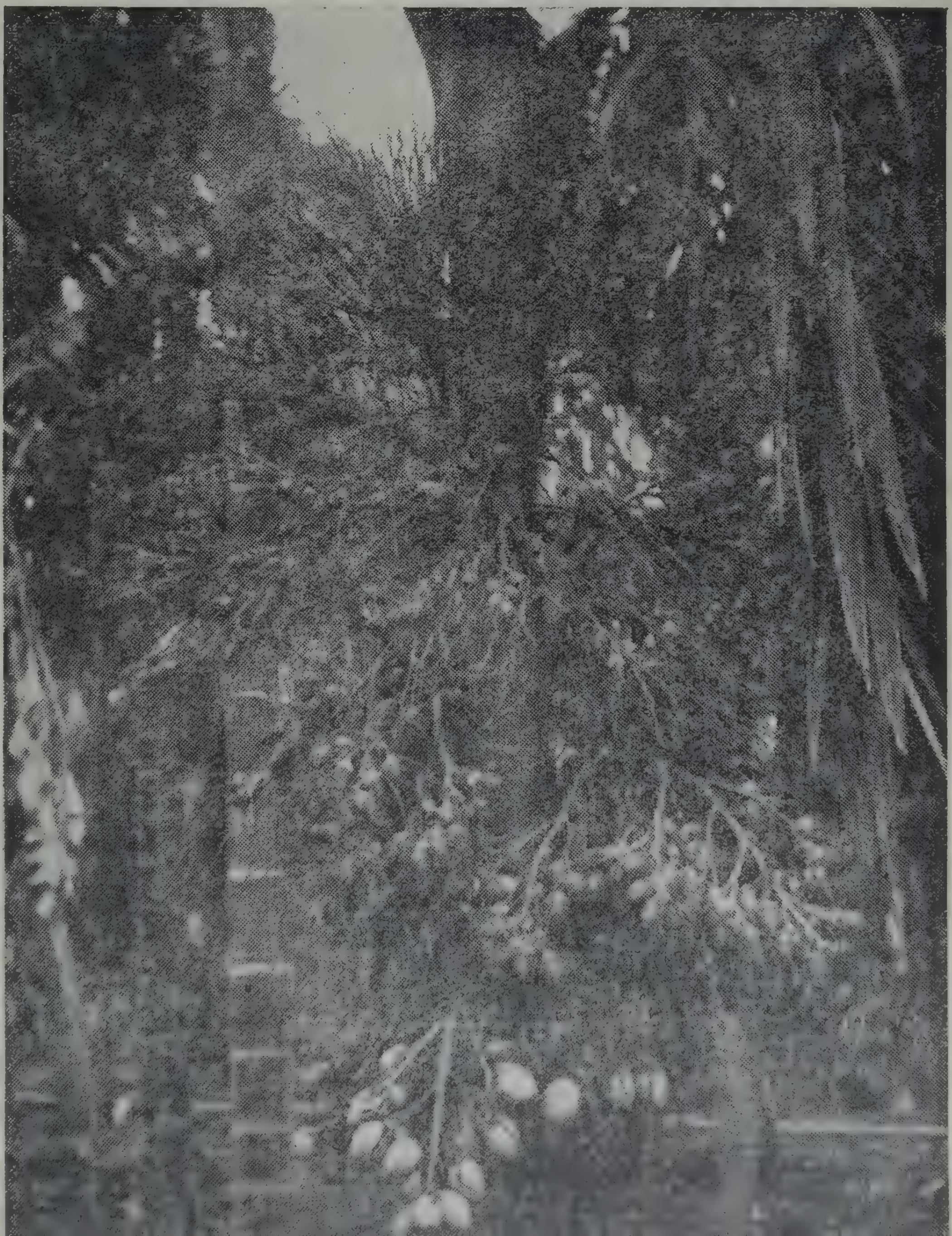


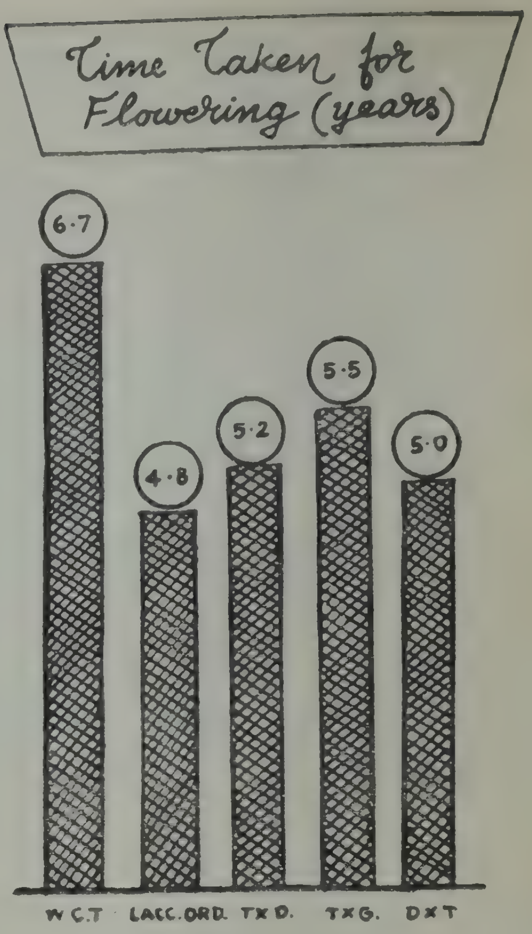
TABLE I. TOTAL PRODUCTION AND AVERAGE YIELD PER HECTARE IN INDIA

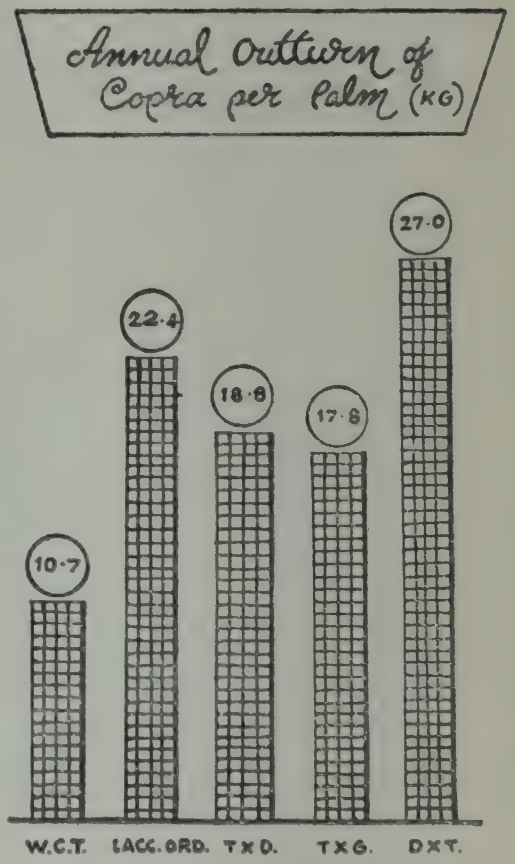
Year	*Production ('000 tonnes)*	*Yield/ha (kg)*
1956–'57	74.75	789
1957–'58	80.58	833
1958–'59	78.21	815
1959–'60	81.86	827
1960–'61	95.46	844
1961–'62	97.11	838
1962–'63	99.00	837
1963–'64	98.46	799
1964–'65	107.51	854
1965–'66	119.90	868
1966–'67	130.10	915
1967–'68	135.40	918
1968–'69	139.10	905

TABLE II. FIELD TOLERANCE OF HYBRIDS TO ROOT (WILT) DISEASE

Name of variety	**Age group*	*Total No. of palms studied*	*Disease incidence (per cent)*		*Average yield of nuts per palm*	
			Age group wise	*Average*	*Healthy*	*Diseased*
Dwarf×Tall (NCD)	1	21	0			
	2	158	1.9	4.6	111.6	46.4
	3	62	12.9			
Tall×Dwarf	1	112	6.3			
	2	121	8.3			
	3	30	16.7	8.4	59.8	24.1
Dwarf orange	1	66	16.7			
	2	222	15.3			
	3	483	20.9	18.9	44.6	24.8
Dwarf green	1	2	0			
	2	48	6.3			
	3	100	8.0	7.3	38.4	11.3
West Coast Tall	1	1133	24.1			
	2	723	64.8			
	3	1108	62.7	48.5	26.2	9.1

*Age group	1	3–7 years
	2	7–15 years
	3	Above 15 years





possible ways of price stabilisation and related handling problems. The Central Plantation Crops Research Institute has reckoned these problems and efforts are on in this direction.

MARCH TOWARDS SELF-SUFFICIENCY IN ANIMAL FOOD

M. L. MAGOON
Director, Indian Grassland and Fodder Research Institute,
Jhansi (U. P.)

Owing to preoccupation of agricultural scientists and rightly so, with the all priority food crops for human consumption, very little attention had been paid in the past to the forage and fodder crops. The sporadic information that was available had not been adequate to make an effective impact on the nation-wide efforts for increased animal production. In the circumstances, the establishment of the Agrostology section in 1947 at the Indian Agricultural Research Institute, at New Delhi, exclusively meant for studies on forage and fodder crops, was, therefore, a landmark in the shape of things to come in this subject.

The enthusiasm of the centre quickly spread to the States resulting in the creation of Agrostology/Fodder Research units to gear up all round research on the subject. Much of the initiative for the creation of these much needed research as also development organisations in the States came from the Indian Council of Agricultural Research, which provided the necessary forum for discussions on the policy matters bearing on the subject through the meetings of the crops and soils and Animal Husbandry wings of the Board of Agriculture in India; financed fodder research schemes and published an urgently required exhaustive and up-to-date review on the "Grassland and Fodder Resources of India." The successful completion of the reconnaissance survey of grasslands in India by the I.C.A.R.; the establishment of Soil Conservation Research Stations in the different agroclimatic regions of the country; of the Central Arid Zone Research Institute, at Jodhpur; of the long overdue Indian Grassland and Fodder Research Institute, at Jhansi in 1962 and the launching of the coordinated research projects both on forage and milk production involving the Centre, and State and Agricultural Universities completed the target of achievement of creating necessary organisation in the country to deal exclusively with forage and fodder crops—a vantage situation, practically absent in the pre-independence era.

All agricultural research is for the benefit of the users of land and therefore has to be conveyed to them convincingly through appropriate measures. The constitution of the Fodder and Grazing Committees in each State, the sponsoring of Key Village Scheme, Intensive Cattle Development Projects, National Demonstration Scheme and appointment of Fodder Development Officers in the States provided the necessary link between the research scientists and the beneficiaries of the results of research. The recent establishment of Regional Fodder Demonstration Centres in various agroclimatic regions in collaboration with the U.N.D.P. authorities provided the final setting to the challenging drama of 'White revolution'.

The tremendous livestock population, the huge gap between the supply and demand for all types of animal food, the preoccupation of a vast percentage of land for food, fibre and cash crops leaving only about 4.4 per cent of the total cultivated area to fodder production, the highly deteriorated condition of the natural grasslands due to overgrazing and faulty management for ages and general lack of interest on forage and fodder crops from farmers arising out of necessity for human food, all constituted a formidable and challenging situation to the research scientists.

Accepting the challenge, the scientists first concentrated on the utilization of the available cultivated area under fodder crops to the fullest extent and a search was undertaken to find out new high-yielding forage and fodder crops and the cultivars of the existing ones through selection or breeding and to work out package of agronomic practices for obtaining maximum production per unit area, per unit time.

Better Fodder Crops

In their search for better fodder crops, the workers at Pusa Institute identified a leguminous fodder, Hubam clover, which, when sown mixed with wheat, not only gave two cuttings of fodder after harvesting wheat, but also its vigorous regrowth could be ploughed in to serve as a green manuring crop, enabling to take a bumper maize crop. Introduction of this legume, thus, could enable a farmer to take two cereal crops, a fodder crop and also a green manure crop without disturbing the

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cropping pattern. Its alkaloid content is also now considered improvable.

Pennisetum pedicellatum, lovingly called Dinanath grass, was another promising find, which in M.P., Bihar, Bengal and Orissa even supplanted the traditionally grown fodder sorghum. Scientists are now busy in locating superior strains. At the IGFRI, Jhansi, a thin-stemmed, multi-tillered strain has recently been isolated, which gives green fodder production of over 1200 q/ha in two cuttings, as compared to about 800 q/ha recorded in earlier introductions.

A multicut fodder sorghum (*Sorghum bicolor*) now popularly called, M.P. Chari, was another useful find of considerable importance. This summer and kharif fodder has low prussic acid content; gives 4 to 5 cuts from March to October; and is also economical in production and management due to good regeneration capacity. The package of practices for this crop were standardized at IGFRI, Jhansi and yield potential of more than 850 q/ha in four cuttings (4 q/ha/day) was obtained in 210 days growth. *Setaria sphacelata*, Guinea grass and para grass are other useful finds with high potential for dairy areas. The common Napier adapted for cultivation in the pre-independence period gave an average green fodder yield of only 850 q/ha. In contrast, the strains of hybrid Napier developed at IARI, New Delhi and also at Dharwar, Coimbatore and Punjab have potentiality of giving over 150 tonnes of green fodder per hectare. It is also a softer grass compared to the ordinary Napier and its high oxalate content and winter susceptibility are now considered improvable.

Based upon the principle that polyploids generally assume exaggerated forms compared to the normal diploid ones, scientists at Pusa Institute, induced polyploidy in the popular berseem crop through known technique of colchicine treatment. The resulting tetraploid berseem, Pusa Giant, was recommended for cultivation owing to its high production, particularly so in the first cutting, unlike the diploid one, which gives a poor yield in the first cutting. Sowing of a mixture of one part of tetraploid and 2 parts of diploid has been found useful in boosting up overall production.

Divergent Stocks

For a further breakthrough in forage production, the need for enlarging the available genetic variability in the various important fodder crops especially from areas of origin and diversity was greatly felt. Thus, as a result of vigorous efforts made at I.G.F.R.I., Jhansi, a large assemblage of divergent stocks of promising forage crops from diverse sources of the world have now been assembled. The collections are continuously being screened and systematically evaluated for various desirable fodder attributes. *In-vitro* and *In-vivo* digestibility studies are also now being increasingly undertaken, besides chemical analyses, in the nutritional evaluation of forage material. Adopting stringent selection measures, a number of high-yielding varieties combining in them several desirable characters have also been identified in cowpea, guar, lucerne, *Mucuna, Dolichos,* jowar, oats, anjan, marvel and Dinanath grass. These promising materials are now under critical tests in the different agroclimatic regions of the country. Extensive hybridization in several forage crops is also actively underway so as to incorporate desirable characteristics such as leafiness, tillering, response to fertilizer application and cutting management in otherwise desirable genetic stocks. The related wild species are utilized for interspecific gene transfer to enrich the cultivated types so as to make them fully suitable for current needs. Besides, new techniques of chromosome engineering polyploidy, mutation breeding and genome approach, are also being employed to achieve the desired objectives of obtaining early maturing, high tonnage, nutritive fodder by incorporating also the built in resistance for diseases and pests. Thus, for instance, while the yield of cowpea grown traditionally as a kharif fodder varied between 150 to 200 q/ha in the past, the scientists at the I.G.F.R.I., Jhansi have identified two highly productive selections yielding over 350 q/ha. They have also isolated a cultivar with a crude protein content of 25% against the normal 15 to 17%. Similarly, in guar also, selections giving as high a yield range of 475 to 585 q/ha against about 370 q/ha have been met with. Likewise, in velvet bean, a type yielding 350-400 q/ha has been isolated. In a dryland pasture legume, *Dolichos lablab* var. *lignosus,* two selections have been identified, giving 250-300 q/ha in two cuts. In *Cenchrus ciliaris,* an important drought resistance pasture grass, an improved selection yielding 403 q/ha as compared to 307 q/ha produced by Pusa Giant Anjan has been identified. Similarly, in Marvel grass, a selection from I.G.F.R.I., produced 758 q/ha of green fodder as compared to 648 q/ha produced by the released var. Marvel-8 from Dharwar. In oats, two promising selections produced 521 and 517 q/ha green fodder as compared to 409 q/ha produced by var. Kent.

Recommendation of high-yielding fodder varieties must be accompanied by a package of practices for obtaining the maximum production per unit area, per unit time, thus ensuring the fullest utilization of the available land resources and the potentiality of the improved genotype. At I.G.F.R.I., Jhansi, application of nitrogenous fertilizer equivalent to 2·25 tonnes of sulphate of ammonia, was found to be the optimum dose for maximum production of hybrid Napier giving a yield of 1800 q/ha of green fodder. Similarly, a package of agronomic practices for maximizing yield in berseem has also been standardized.

Over-Lapping Cropping

Based on these two crops a cropping system called "overlapping cropping" has been devised for intensive dairy farmers to provide high tonnage of good quality green fodder throughout the year. The system consists of mixed cropping of berseem (25 kg/ha) with Japan *Sarson* (3 kg/ha) in winter and interplanting in the first year with hybrid Napier in spring and growing companion crops of cowpeas. A production target of 2800 q/ha has been reached averaging about 8 quintals per day sufficient for 15 high producing milch cattle under Jhansi conditions.

The strategy of split application of fertilizer has also been found to hold the key to the breakthrough in fodder production. Application of 60 kg/N/ha basal followed by that of 150 kg N/ha in three splits gave a record yield of over 850 q/ha in case of fodder sorghum, M.P. Chari in four cuttings.

Furthermore, efficient and economical fodder conservation techniques have also now been standardized to conserve the surplus fodders produced during the peak period of maximised production under the overlapping year around intensive fodder production system. In formulating balanced feed for sustained animal production throughout the year, such conserved fodders, thus, play a very crucial role especially to feed animals during the two lean periods of fodder production in India. The gap in the supply is best met with by either hay or silage. Using galvanised woven wire fencing material, an efficient and low cost method of good quality hay production has been developed at I.G.F.R.I., Jhansi, and excellent hay from berseem, lucerne, cowpeas, oats and some other crops has been prepared on a large scale. Berseem, a crop difficult to conserve owing to its high moisture content, has also been successfully utilized for making silage by pre-wilting it to 42 per cent dry matter and adding 10% wheat bran. The silage was highly relished by animals.

Along with package of practices for a high fodder production and suitable conservation, scientists also devoted attention to improving the food value of the crop residues, which still forms a major source of animal nutrition. Recognising the importance of wheat bhusa in the present animal feeding schedule, the scientists at I.G.F.R.I., Jhansi set about for improving its quality through ingenious cultural practice. By growing common 'Vetch' closely related to the local 'Chatari Matari' in wheat fields and harvesting and thrashing the mixed crop, the legume still in luscious green stage, the protein, calcium and phosphorus content of the bhusa of a local wheat variety was increased to 6·3%. 0·75% and 0·54% from 3·5, 0·23 and 0·24 per cent respectively, in pure wheat bhusa. The association of vetch also increased the yield of wheat and also of the following fodder crop of M.P. chari. This practice has an advantage in that it does not disturb the farmers normal cropping programme and thus holds a great promise. Likewise, growing of M.P. chari and cowpeas in alternate strips of 2 rows each resulted in 1500 kg/ha more crude protein as compared to chari alone. A culture of cowpea having an erect plant habit and capable of growth under high population density has been selected at I.G.F.R.I., Jhansi for mixed cropping with cereal fodder crops.

With the growing interest in fodder production, the demand for quality seed has already increased considerably. Fodder crops by nature, are generally shy seeders and in order that lack of availability of good quality seed may not adversely affect the recent healthy attitude towards fodder crops, the Institute at Jhansi made concerted efforts in this direction and a spectacular breakthrough has been achieved in the seed production technique. The trick was done by the growth retardent, CCC (Cychocel). Spraying at 15-20 days before flowering with $\frac{1}{2}$ kg a.i./ha in fodder sorghum, M.P. chari and with 2 kg a.i./ha in oats, the seed yields were increased from 6·3 to 15·4 q/ha in the former and from 11·8 to 27·4 q/ha in the latter. In the leguminous fodder crops like berseem, spraying of single superphosphate as 4% P_2O_5 solution at the rate of 100 litres/ha i.e., 40 kg P_2O_5/ha as well as composite spray of micronutrients (Fe, Cu, Zn, Mo, B and Mn) at 100 ppm at the rate of 800 litres/ha resulted in 40 to 50 per cent increase in seed yield. The spraying is done 15-20 days after taking the third cut. Similarly, in cowpeas, foliar spray of single superphosphate at the rate of 25 kg P_2O_5/ha at first flush of flowering increased the seed yield by 30 per cent.

Minimum Cost

In order that animal products are brought within the reach of people of all status, the cost of production of the fodder—the basis of animal production—must be brought down to the minimum. Efficient implements whether bullock or tractor drawn thus become necessary in any production programme. To this end, a number of simple implements have been designed at I.G.F.R.I., Jhansi to bolster the "grow more fodder campaign". Irrigation-cum-channel former is such an implement which can make a channel or bund of a desired size in a single operation against four in the former and two in the latter with normal implements resulting in a saving of Rs 18 to 24 ha with a further saving of 50 to 60 per cent in terms of time factor. A country plough seed drill has been designed for sowing special fodder crops on ridges as in the case of lucerne in heavy soils. A 'smoke screen former' has also been designed to protect valuable forage germplasm material from frost. This can also be gainfully used for vegetable and truck crops.

Berseem seed is generally contaminated with the seed of a noxious weed Chicory. A simple mechanical device has been built using to the best advantage the differences between the surface characteristics of the two types of seeds. Berseem with a rounded seed gathers an early momentum on an inclined plane and reaches the collecting end long before the conical Chicory seeds reach half the leg length. A 98% purity has been obtained with this simple mechanical device.

It is well-recognised that seed collection in grasses is laborious and time-consuming. A simple mechanical equipment has been designed which increases the rate of grass seed collection by about 25 times as compared to hand picking by a manual labour.

The efforts and achievements in the fuller utilization of available land were also matched with efforts in understanding the basic problems involved in the development of the vast grassland resources of the country and formulation of policies in increasing the grassland production. One of the landmarks in the subject concerning grasslands during the post-independence period is the changed outlook of all concerned. Grasslands are no longer considered as the national bank from which unlimited supplies could be drawn without deposits being ever made. Similarly, grass is no longer considered as a vegetation, which comes up automatically on the onset of monsoon, provides grazing to cattle and then dies out, but as a crop needing all the care and attention due to a crop.

Types of Grassland

Grassland survey carried out in a scheme sponsored by ICAR during 1954 to 1962 not only recognised the occurrence of five distinct grass covers in the country, but also provided a detailed and authentic information on the types of grasslands occuring in different parts of the country; the soil, rainfall and other climatic factors associated with the covers and the different grass communities in each grass cover, their relative status in the process of development and the principles of their scientific management. As a result of such information, a breakthrough in the grassland production has been achieved through manuring of grasslands, a practice unthinkable in pre-independence period due to lack of fertilizers. The application of 40 to 60 kg N/ha increased the production of hay from 35 to 40 q/ha to as much as 75 q/ha in certain grass communities of *Sehima-Dichanthium* cover bringing in a net return of over Rs 500/ha under Jhansi conditions. Similarly, in cultivated Anjan (*Cenchrus* sp.) grass pastures, a record production of almost 100 q/ha of hay has been reached through the application of 90 kg N/ha allowing about 20 sheep to graze all the year round. Grassland farming, thus, promises to give an upper hand in arid and semi-arid regions where the normal crop husbandry generally proves a gamble.

Uncared grasslands generally abound in shrub growth to the extent of 30 per cent of the grassland area. The presence of these bushes drastically reduces the grass production. A complete kill of brush has been achieved by application of 0·4 per cent solution of 2, 4, 5-T amide/ester on cut stumps. Another newly obtained herbicide picloram has also shown great promise.

Equally spectacular results have been achieved in the improvement of the quality of grass hay. Indian grasses are poor in quality and grasslands lack in pasture legumes which are rich in nutrients. Introduction of the Australian selection of the legume 'Siratro' (*Phaseolus atropurpureus*) and a local legume '*Bankulathi*' (*Atylosia scarabaeoides*) raised the protein content even in the ripe stage from 2% in pure grass to over 6% in the mixed herbage. Broadcasting of pelletted and scarified seed with 20 kg P_2O_5/ha in premonsoon, with or without harrowing, gives a good establishment of these legumes. Use of grazing animal as a seed disseminating agent has also given an interesting lead.

Pasture grasses are also shy seeders and, therefore, seed production techniques were given special consideration. Application of 40 to 60 kg N/ha has been found to increase the production by over 300% in different grasses. In *Cenchrus setigerus*, the response to nitrogen application was very effective in increasing the seed production from 23 to 143 kg/ha with the application of 40 kg N/ha.

The forest departments, the custodians of most of our grasslands, have also now shown considerable interest in the improvement of grassland to boost up their revenue earnings from degraded forests and degenerated grasslands at the same time to share the responsibility of feeding the livestock in the country. This awakening is a good augury for increasing the grassland resources of the country.

The lead given by the green revolution on the food front will no doubt inspire the scientists in their dedicated march towards self-sufficiency in animal food so eagerly and hopefully awaited by the nation and which alone provides the anchor sheet for the realization of the 'White revolution'. Some breakthrough has already been achieved, much still remains to be done, more so in the temperate region with very high potential for animal production. The challenge we have accepted, and the machinery now created for research and development will slowly but surely take us to one cherished goal of self-sufficienycy in milk, milk products, meat, wool and other animal products so urgently needed by the nation.

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RAGI IN MYSORE STATE

C. KEMPANNA

Assistant Director-General, I.C.A.R., New Delhi

RAGI, botanically called *Eleusine coracana* Gaertn., has been one of the most ancient crops of the Indian sub-continent, valued for food and fodder. Although it has been distributed practically all over India, it is very much concentrated in the southern states, more particularly in Mysore. The larger area under this crop together with a greater intra-specific diversity in respect of morphophysiological systems suggest that ragi is possibly endemic to Mysore region.

Research Programme

A comprehensive research programme with multiple objectives had been launched by about the middle of 1960's with the active association of the Rockefeller Foundation in India. A large collection of *E. coracana*—both indigenous and exotic—constituted the nucleus material. A systematic screening of the germplasm yielded a variety UAS-1 with a reasonable amount of resistance to the disease complex. But by being agronomically not so very desirable, it had to content itself by remaining a source of resistance to, what seemed at one time, a more formidable disease. Another variety that came out more or less at the same time was *Hamsa* whose grain was peach coloured but rich in protein and calcium contents. The peach colour which is not much of a consumers' preference together with no obvious additional yield advantage to its credit, *Hamsa* could not edge over the existing varieties. Yet it constituted a source material for breeding for nutritive quality of the rain.

Intensive research, however, continued unabatingly for the genotypes endowed with high yield structure, general adaptability and resistance to some of the common diseases, particularly to the disease complex. While the rigorous laboratory and field techniques were made use of to screen the material for disease reaction, sophisticated biometrical parameters were applied to test the innate genetic strength for high yield structure on one hand and the physiological frame for general adaptability on the other. Sufficient information has been gathered to establish the relationship between yield and various plant attributes. Amongst others, grain bearing area of the panicle, in other words, spikelet number, is shown to have a greater sway on the yield. Considerable amount of diversity occurs with the natural population in respect of grain bearing area, but some of it is environmentally governed. But, a very high genetic gain, much more than for any other yield component, is predicted for this character because of its very high heritability value even after the elimination of the environmental as well as the interaction (Genotype × environmental) components from the total variance. Using this parameter as a reliable criterion, selection was exercised directly and repeatedly and a few promising strains like HES-927, HES-928 and HES-929 were built up from amongst the African material and *Annapurna* from Mysore material. All these strains were found decidedly superior to the local strains in their yield and, in fact, on an average, the first three strains have yielded under irrigation around 24 to 25 quintals per acre which amounts to 40 to 45 per cent enhancement over the superior local strains. The yield of *Annapurna* is though not so much as these, it is decidedly better than the locals.

Adaptability is an important aspect with *ragi* as it has to adapt to different seasons (kharif and summer) as well as to different cultivation systems (dry land and irrigated system). As a result of testing the material for adaptability, evidence is available to recognise five different categories: (1) average adaptability (2) general adaptability (3) poor adaptability to all the environments (4) specific adaptability to high-yielding environments and (5) adaptable specifically to low-yielding environments. The interesting adaptability pattern from the point of view of crop improvement is the general adaptability. This means that the varieties under this category have an innate capacity to stabilise themselves against fluctuating environmental conditions and produce above average yields.

Amongst others tested for adaptability patterns, HES-927 and *Annapurna* have shown the pattern of general adaptability. The yield of HES-927 series (HES-928 and HES-929) under rainfed conditions are around 10 quintals, which amounts to 110 to 120 per cent increase over the traditionally cultivated varieties like H_{22} and *Cauveri*. With these yield levels under irrigated and dry land cultivation systems, there is every reason to believe that ragi can stand competition with any of the high-yielding varieties of more progressive crops like maize, wheat, sorghum and bajra.

Disease problem is a formidable one. HES-927 series have shown remarkable capacity to withstand the incidence of the disease complex and of blast under field conditions; whereas *Annapurna* in its present form has to be suspended from the list of the recommended varieties because of its susceptibility to disease complex even inspite of the fact that it is shown to have all the desirable qualities like yield and adaptability.

Nutritionally, HES-927, HES-928 and HES-929 are on par with or slightly better than that of *Purna*, a locally cultivated standard variety.

Mere evolution of high-yielding varieties like HES-927, HES-928 and HES-929 is not the end in itself and particularly not so with ragi since these varieties do have certain defects, like the high-yielding varieties of all other crops, which need rectification in order to make them more acceptable. Some of the defects like long maturity period, grain size which is not ununiform, and nutritive quality of the grain have now got to be tackled on an urgent basis in order to fit them into the revolutionary agricultural patterns that are sweeping across the subcontinent. The levels of yields achieved presently with these varieties may not certainly be the maxima in view of the fact that the grain bearing areas of the head which showed greater correlation with yield and very high predicted genetic gain exhibits a considerable amount of still exploitable variation. Ragi is known for its nutritional values as it constitutes a good food for working class, infants and diabetic patients. Variation in respect of this character now evident with the natural populations should provide greater scope for further improvement in nutritional quality of the grain. Disease and pest problems are attaining major importance. By exploiting the natural variation both at the specific and generic levels, the varieties can be fortified against this onslaught. Since ragi is predominantly a dry land crop, greater emphasis has now got to be placed on drought resistance. Component analysis has sufficiently indicated that there is considerable scope for the improvement of yield and yield attributes under dry land conditions through positive breeding efforts. It is well-known that ragi has a remarkable capacity for drought tolerance. However, it can be further intensified through the exploitation of alien gene potential.

The work in this direction is already in progress in various centres of the State as well as elsewhere outside the State. While the intraspecific hybridization involving the indigenous varieties (Indian) as well as that involving indigenous and exotic (Indian × African) is expected to bring certain measure of necessary improvement, the mutation breeding and the other sophisticated breeding techniques would, however, become complementary in achieving the major goal. What is most essentially wanted is a concerted effort of the breeder, agronomist and the plant pathologist together with the liberal material resources. Given these, there is no doubt that ragi would never lag behind, in its productivity, the more progressive hybrid crops like maize, sorghum and bajra.

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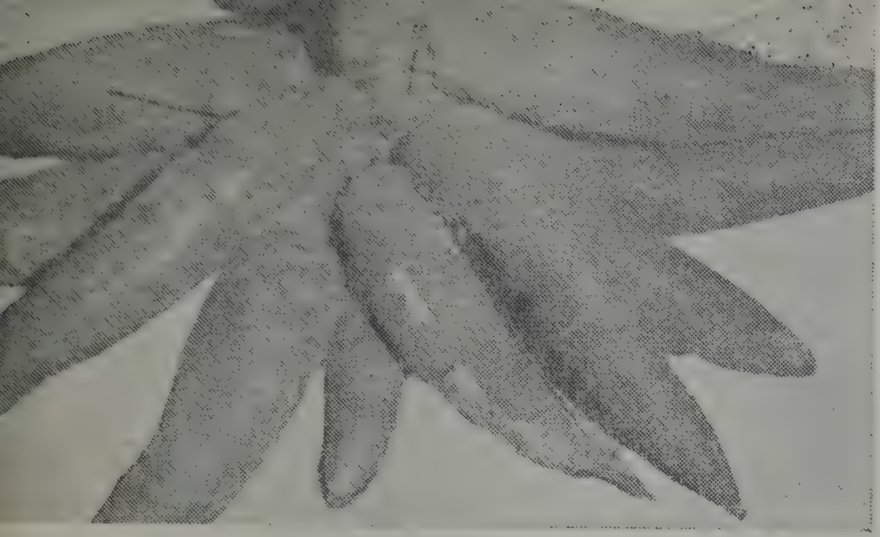

Cassava (tapioca) — Hybrid 165

TUBER CROPS IN INDIAN ECONOMY

H. HRISHI and R.G. NAIR
Central Tuber Crops Research Institute, Trivandrum

Realising the importance of the various tuber crops in the national economy, the Central Tuber Crops Research Institute was established in 1963 with headquarters at Trivandrum.

A wide range of comprehensive and well-integrated technical programme keeping in view the requirements of farmer, consumer and industry have been undertaken in the Institute. The well-planned approach on the problem and production oriented projects has paid rich dividends.

Among the general tuberous and rhizomatous crops, grown in India, cassava (Tapioca), sweet potato (shakarkandi), yams (*Dioscorea*), aroids (*Colocasia, Alocasia, Xanthosoma*), *Amorphophallus* (Elephant foot yam), *Coleus* arrow root (*Maranta*), *Curcuma* and *Canna* sp.) and turmeric are the important ones. The average yield of cassava in India is 100 to 120 q/ha and that of sweet potato 20 to 80 q/ha. Other crops like *Amorphophallus, Coleus, Colocasia, Maranta*, etc. yield 20 to 80 q/ha. These yields are very low as compared to the yield registered in other tuber crops growing countries and the average yield can no doubt be increased to two to three-fold with the use of improved varieties and better agronomic practices. For any improvement programme production forms the fundamental basis and for which a good genetic variability is a must. Having a very much diversified origin and geographical distribution, variability in the genetic stocks of the different tuber crops is quite high. This variability can be successfully exploited by selection and by hybridization, among indigenous types as well as between indigenous and foreign types. With this objective in view a good number of collections from diverse sources within the country and from outside have been made. Thus at present we have 1300 collections of cassava of which 250 entries are from countries like Brazil, Madagascar, Tannanarive, Senegal, Uganda, Malaya, Ceylon, Fiji, Ghana, Gabon (France), Columbia. There are 410 collections of sweet potato, 200 in *Dioscorea*, 300 in Aroids *Amorphophallus*, *Coleus* and Arrow root, and these are being screened for desirable characters. Based on desirable plant type with higher yield sweet tubers, field resistance to cassava mosaic disease, good cooking quality, varieties were isolated. Selections S-1309, S-1310, S-1315, S-2371, S-2380, S-1407 from the cassava materials have been found to be promising.

As a result of intensive intervarietal hybridization involving exotic and indigenous types, which is proved to be the superior breeding strategy to obtain new recombinations, promising hybrids viz. H-165, H-86, H-97, H-43, and H-226 have been evolved. Of these H-226, H-97 and H-165 are much superior with yields ranging from 235 q/ha to 845 q/ha as compared to the tuber yield of 200 q/ha in local varieties. In H-97 the tubers possess high starch content up to 30.8% on fresh weight basis.

Polyploidy breeding has also been found to increase the percentage of protein and the tetraploids of the variety M-4 has registered an average crude protein value of 3.97% as compared to 1.8% in diploids. Thus, this opens a fresh scope for enhancing the quality of the tubers with reference to protein. Attempts are being made to increase the protein value of the high-yielding varieties by tranferrring the protein genes from a variety (8.3% protein on day weight basis) from British colombia.

Sweet Potato

Attempts are being made to develop improved sweet potato varieties by adopting selection and hybridization techniques to achieve higher tuber yield, higher starch content, higher sugar content, higher carotene content and resistance to weevil. The diverse sources available at the Institute are being screened and evaluated for several economic characters for utilization of the genetic variability.

A large number of hybrids have been produced. Critical screening of the hybrids led to the isolation of strains with vigour, possessing desirable agronomic attributes. Among them three hybrids viz. H-41(2), H-42(1) and H-42(2) have been found to be excellent yielders, their

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yields ranging from 250 to 370 q/ha. The starch content of H-42(1) is higher i.e., 23% as compared to 19% in the local variety. Further, this hybrid shows 3.0% sugar content on dry weight basis which is twice than that found in the local variety.

The significant increase in the protein of improved varieties is of considerable importance to compensate the nutritional gap, which is found in tropical regions. Among these hybrids, H-42(2) has also been found to be an early maturing variety and becomes ready for harvest in 105 days.

These hybrids have given very high yields in different locations not only in Kerala but also in the States of Tamil Nadu and Orissa. Besides these hybrids, several other promising hybrids are being tested for their yield performance in different multilocations and very soon it is likely that some of these promising high yielding strains will reach the farmer, when once the critical testing is over.

Dioscorea. It is a crop having diversified origin and very high genetic variability. Attempts to utilise this variability through selection and hybridization have been taken up. It is also felt that further collection of edible exotic species cultivated in America and Africa which are esteemed for their tubers are highly essential.

Aroids. This group consists of *Colocasia, Alocasia, Xanthosoma, Amorphophallus.* Scope of hybridization in these crops is rather limited due to high female sterility prevalent among local cultivars, though difference in yield potential is noticed among the cultivars. Quality factors are very important due to the presence of irritating principle in the tubers. Selections are being practised among the genetic stocks to get types free from these defects.

Arrowroot. Arrowroot is a collective name for three types of tubers, i.e. *Maranta, Curcuma* and *Canna.* These are crops, which have received only scanty attention. In view of their value as food especially for invalids and convalescents and in use in various industries, these crops should receive attention towards improvement. Recently programmes are being initiated for the genetic improvement. Collections of different cultivars from diverse sources have been undertaken for evaluation of desirable characteristics.

Cultural Practices

The present level of production of tuber crops in India as stated earlier is low although some of them have the ability to give high economic yields. Once high-yielding variety is evolved the best utilisation of the same and the total extraction of its resources lie in the hands of scientists of agronomy and the agriculturists. Hence, it is imperative that improved methods of cultivation to suit the needs of different agroclimatic regions in respect of particular varieties are evolved. Several investigations were conducted to determine the optimum agronomic practices such as nature of planting materials, method and type of planting, optimum spacing, plant population, etc. with regard to different tuber crops. Several cultural techniques have thus been evaluated and standardised. Optimum manurial requirements of some of the recently evolved hybrids have also been determined. Based on extensive manurial trials in cassava, a dose of 100 kg N, 100 kg P_2O_5 and 100 kg K_2O per hectare in combination with 12-15 tonnes of farmyard manure has been found to be optimum for maximising the yield. Among the different sources of N, P and K fertilizers used, calcium ammonium nitrate as nitrogenous source, Thomas phosphate (basic slag) as phosphatic source and muriate of potash as potassic source were found superior to other forms of fertilizers tried in this crop. Inter cropping of groundnut and cowpea in between cassava rows did not affect the normal yield of the main crop and was found to be a very profitable practice.

The results of the manurial trials conducted on high-yielding strains of sweet potato suggest that 75 kg nitrogen, 50 kg phosphorus and 75

Dioscoria alata

kg potash in combination with 10 tonnes FYM/ha will be the optimum dose for obtaining higher yield and better quality tubers. A manurial dose of 100 kg N, 50 kg P and 100 kg K along with 12 tonnes of F.Y.M. for *Colocasia* and 40 kg each of N and P and 80 kg K in combination with 12 tonnes of F.Y.M. for *Amorphophallus* was found to be the economic dosage for obtaining higher quality tuber production.

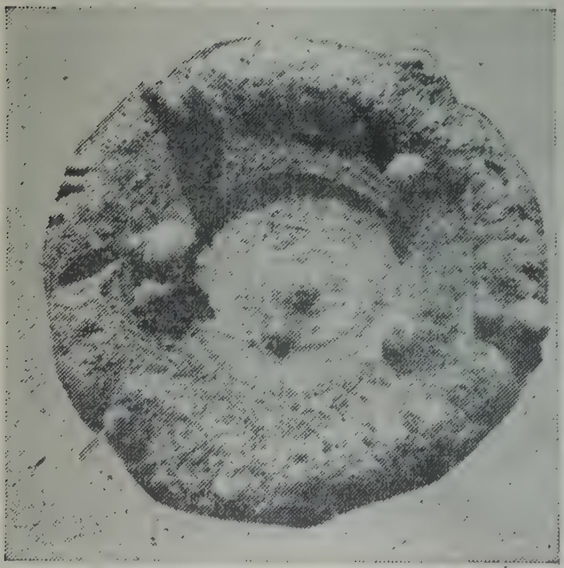
Crop Protection

Several of the root crops with the exception of perhaps sweet potato in our country are comparatively free at present from ravages of very serious pests and diseases which take a heavy toll of many other food crops. Cassava is resistant to deadly locust attack in highly locust infected areas in Africa. Among diseases of cassava, cassava mosaic is probably the only virus which is attaining serious proportions, of late, in certain parts of Kerala, but it can be controlled by using stems of resistant strains for propagation. The disease is apparently transmitted by the insect vector *Bemesia* sp. (the white fly). Spraying of 0.03% dimethoate (Roger) or Endrin 3 to 4 times at monthly intervals in the first four months of the crop have been found to control the vector and thereby control the spread of the disease.

The leaf spot disease caused by *Cercospora henningsii* is characterised by formation of round necrotic spots on the leaves, causing extensive defoliation in susceptible varieties. This disease can be controlled by spraying Bordeaux mixture.

Arrow root

Amorphallus (Elephant foot yam)



The sweet potato weevil *Cylas formicarius* is the important pest causing damage to the tubers of Sweet potato. Field experiments conducted using several chemicals have shown that spraying of 0.1% Sumithion or metasystox at monthly intervals commencing from one month after planting or applying Solvirex granules 25 kg/ha during the second month of the crop will bring the pest under control.

Coordinated Trials

In view of the urgencies of stepping up food production and considering the increasing utility of the tuber crops as subsidiary food, industrial raw material and livestock feed, it was felt that undertaking large scale multilocation tests of the promising breeding materials will be helpful in bringing out the full-yielding potentiality, adaptability and environmental resilance of the material under various stages of evaluation. Hence coordinated varietal trials were laid out by the Institute in cassava and sweet potato at several locations in Kerala, Tamil Nadu, Mysore, Orissa and other places and in response to urgent demands from the various workers representing different States, trials are being extended to enable additional locations in other States as well. It is very interesting to note that the cassava hybrid H-97 which yielded 35.1 tonnes per hectare on an average for 9 centres within the Kerala State yielded more than two times producing a record yield of 84.7 tonnes in Bangalore under irrigated conditions thus revealing the yield potential of this variety. Almost all the varieties tried in this Station have given very high yields compared to their performance in other centres (Table 2).

National Demonstrations. To convincingly demonstrate to the farmers the impact of the high-yielding varieties and the adoption of modern technology and scientific methods of cultivation of these crops, demonstration plots were laid out in the plots belonging to willing and cooperative farmers representing average size of the holding in the areas. Five plots were thus laid out in the year 1970-71 on cassava and 7 plots on cassava and one on sweet potato were laid out in the year 1971-72. The results also clearly indicate that the varieties evolved and recommended for cultivation are definitely better yielders.

Future of Tuber Crops in India

In coming years we can look forward to great accomplishments with regard to the tuber crops provided we pay simultaneous attention to all aspects of its genetic improvement followed by adoption of scientific cultivation and extension. The prominence of starchy root in the dieteries of the developing countries results essentially from the large amount of food calories they yield per unit area of land. In a developing country with a growing population and a rising per capita income, increasing demand for land will result in search for high-yielding crops in terms of calories and it is in this field that the role of tuber crops became important. Cassava is the sixth most important staple food in the world today, in terms of weight produced and it is likely to be exploited even further in the future by developing nations. In the realms of industrial processing cassava may well be farmed because it produces more starch per acre per year under relatively dry conditions than any other crop known. The place of cassava in this aspect has begun to be recognised and this crop which was previously confined to Kerala has now been introduced in large scale in other states also. This crop which was growing only in 3 to 4 districts of Tamil Nadu has been gaining popularity year after year and at present it is under cultivation in almost all districts of Tamil Nadu. More than 300 units are functioning in the Salem district alone of this State for production of Sago, Starch, Samolina, etc. With the introduction of new high-yielding hybrids having high starch content and establishing more starch and sago factories the scope for increasing the area under this crop is developing in the State of Andhra Pradesh. Cassava is normally grown in Assam and in some parts of it, it has begun to be cultivated as a staple food.

There are further possibilities for extending this crop to States like Maharashtra, Gujarat, etc. where chances of utilization as an industrial raw material exist. Cassava also forms an important source of cattle feed especially for milch animals, for poultry and piggery. Coming to application of starch in chemical industries, its utilisation in industries like paper, glucose and dextrine, cosmetics, pharmaceuticals, fire proofing preparations and fermentation of alcohol, etc. have to be specially mentioned.

Sweet potato is also widely used in India as food after boiling, baking and frying. In the U.S.A. considerable quantities are canned after pealing. Sweet potato flour is often used in preparation of *phirni*, biscuits, cakes, pudding, etc. Japan utilises Sweet potato exclusively for starch production and its starch is widely used in various industries. Dried or dehydrated sweet potato are also considered useful source of carbohydrate rich feed for livestocks.

There are possibilities of utilising yams which are at present only consumed in the form of tubers, for other commercial and industrial purposes. Starch is extracted in commercial scale from tubers of *D. alata*. Many wild species have been found to be sources of sapogenins having a steroid nucleus. These steroids are finding increasing use in the synthetic drugs such as cortisone, birth control pills and in sex hormones. The sapogenin most commonly found in diosgenin, which is particularly favoured as a starting point for drug synthesis.

Arrowroot comprising more than one genus viz. *Maranta, Curcuma*, etc. form another group of tuber crops valued for the starch obtained from their rhizomatous tubers. Arrowroot starch is valued as food especially for infants, invalids and convalescents. It is also employed in the production of biscuits, cakes, pudding and jellies and as a suspending agent in the preparation of barium meals.

Cassava leaves form a popular item of food in Africa where the leaves are cooked and prepared in many different ways. Considering the high protein content (28%) of the leaves there is vast scope in its utilization in the preparation of different dieteries. Likewise, sweet potato leaf which is sometimes used as a vegetable, is said to contain 4% protein, a reasonable amount of iron, calcium and phosphorus. A small quantity of ascrobic acid is also present. Young leaves and stalks of *colocasia* are good source of pro-vitamin A and vitamin C.

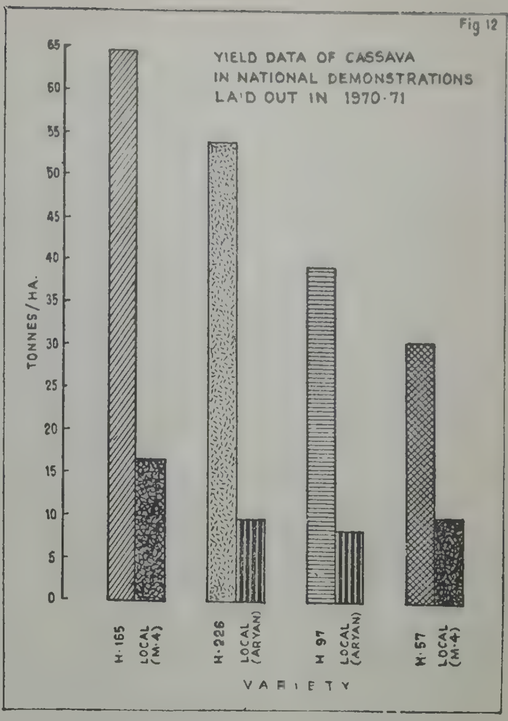


Fig 12

Though the tuber crops do not earn much of foreign exchange, it no doubt saves considerable amount of foreign exchange. Prior to the last world war, entire quantity of starch required in the country was imported. During the war import was completely banned and textile industry has to fall back upon its internal sources. This position still continues saving good amount of foreign exchange. However, there is vast scope for export of these products to other foreign countries such as U.K., Belgium, Australia, New Zealand, West Germany, etc. Even as early as 1959-60 sago was exported to Ceylon, East Pakistan and Russia from many of the Indian ports.

Considering the salient features of the tuber crops and the vast scope for their development as multipurpose crop there is a strong case for enhanced attention to their improvement.

Contribution of Sugarcane Breeding Institute

S.S. SHAH
Director, Sugarcane Breeding Institute,
Coimbatore

SUGARCANE Breeding Institute which started in 1912 as a research station, has been the main source for the improvement of sugarcane varieties in the country. Since seed setting and flowering occur satisfactorily mainly at Coimbatore, in contrast to other crops, the breeding work for the entire country has been mainly confined to Sugarcane Breeding Institute, Coimbatore. At Pusa, Bihar, also they have succeeded in obtaining seed setting and flowering and they are carrying on a limited programme there, primarily for their own state.

The breeding programme carried on at Sugarcane Breeding Institute has two main approaches:—

(i) The crosses are made at Sugarcane Breeding Institute, and the selection in the progeny is carried out lasting for 3 to 4 years and as a result of this, 10-20, sometimes more, genotypes are selected and sent to various sugarcane growing states in the country to carry out further selection there. Selection in states takes nearly 6–8 years, in some cases even nearly 12 years. Varieties evolved as a result of this procedure are the Co. canes.

(ii) The crosses are made and the fluff (hybrid seed) is supplied to various states to carry out selection in various agro-climatic zones, where the variety is to be released. The varieties obtained by this procedure are given Co. S. (Coimbatore-Shahjahanpur), Co. J. (Coimbatore-Jullundur), etc. numbers.

In its breeding efforts Sugarcane Breeding Institute has been quite successful, as could be seen from Table I giving the latest available sugarcane varietal census data for the most widely grown varieties in various states.

Except in Bihar and to some extent in Uttar Pradesh, in all other States, by and large, Co or Co.J., Co.S., etc. varieties are grown.

According to the latest compiled data Co. varieties are commercially grown in 26 other countries in the world. The main reason for Coimbatore Institute being successful in producing varieties which are adapted to such diverse climatic conditions in India and foreign countries, is probably the wide genetic base used in the breeding programme. Genetic bases have come from more than one species. It is of interest to note that it has been now shown that in cross pollinated crops wider genetic base is associated with wider adaptability (Allard and Bradshaw, 1964).

In recent times one of the varieties which has become very important in U.P. is Co. 1148; in Western U.P. it occupies more than 80% of area at present. This is because of its resistance to red rot, high yield and other desirable characters.

In sugarcane the introduction of a new variety is a slow process as compared to other crops such as wheat and rice. Hence the replacement of older varieties takes more time in sugarcane. As has been mentioned above from crossing to placement of a variety on approved list, it takes 10 to 15 years. Partly this is because of low multiplication rate and one year life cycle. Also with multiplicaion rate being around 10 only, as compared to 100 or so in rice and crop cycle being of one year, it would take considerably longer time to saturate the area with the variety. We have initiated steps to cut down this time, such as increasing the multiplication rate by methods such as short cropping, carrying out the selection on a more wider scale in agro-climatic zone concerned from the beginning thus saving time in selection programme, opening up a dialogue with States to reduce time for testing Co. canes, etc.

In view of this longer time taken, the Table 1 giving varietal census for widely grown varieties will not give performance regarding the varieties released in recent past.

The 1965-66 census also includes a large number of varieties occupying lesser area and in the origin of which this Institute has been associated. Many of these have been released from this Institute in '50s and placed on State approved list after testing in respective States for 6 to 12 years. Important among them are: Co. 1148, Co. 1158, Co. 975, Co. 997, Co. 897, etc.

Comprehensive details regarding acreage are not available after '65-66, but the approved list of varieties for 1970-71 for various States includes 41 Co. canes, 13 Co.S., Co.J. and

Fig. 1 A

Co.L. canes, 13 B.O. canes and 3 I.C. and H.M. canes (released from Mysore State). These include several varieties released from this Institute in '60s. This again shows the important role of Coimbatore Institute with respect to varietal improvement.

These varieties have become popular because of several desirable characters in them. Many of them high-yielding types such as Co. 419 grown in Tamil Nadu, Andhra Pradesh, etc., and Co. 1148 and Co. 1158 grown in northern belt, others are early, i.e., give high recovery in early part of crushing season of factory; they include Co. 658 which is getting popular in Tamil Nadu, Co. 997 in Andhra Pradesh, Co. 1336, Co.J. 58 and others in northern belt. Some of them are resistant to the most important disease in India, namely red rot, e.g., Co. 1148. Others have other desirable characters such as resistance to smut, resistance to insect pests, drought and frost resistance, retention of high recovery for a long period, flood and waterlogging resistance and other economic characters to make them suitable for diverse climates in cane growing areas we have.

This success calls for more intensive and renewed efforts for the next generation of varieties. We have taken several measures in this direction. We have intensified the selection from beginning in agro-climatic zone concerned by supplying fluff to 14 centres instead of 5 centres earlier. More intensive studies on testing of available germplasm (types to be used in crossing to improve existing varieties), such as studying the economic character concerned in the area where it expresses the most, finding out the proportion of desirable types obtained at the final stage of selection in the progeny of each of the parent, etc. have been taken up. We have carried out several improvements in our main breeding technique, i.e., biparental mating to evolve varieties which are more appropriately fitted to the modern needs. These include a specific programme for early varieties which will give high recovery in early part of crushing season of the factories, selecting for diseases primarily on basis of the prevalence of particular diseases in the State concerned, use of more powerful experimental designs, etc. We have also started using more intensively more powerful breeding techniques than biparental mating. These include recurrent selection, back-cross method of breeding, mutation breeding and use of inbreeding. These efforts would certainly help us in evolving appropriate varieties with appropriate plant type for various regions in the country.

The salient features of the work done and important lines of work in future by various sections in the Institute on other aspects are given below. Some of this work will be of direct use to breeding.

Genetics

Several qualitative characters were studied with respect to inheritance. These include presence of circlet of hairs at nodes, type of spikelet, awning, etc. The inheritance ratios ranging from monogenic to those involving up to three genes were found. Using techniques such as sib-analysis and parent-progeny regression, subsequently, the work was started to study quantitative characters. Using parent-progeny regression method 8 characters such as germination per cent, stalk height, brix, sucrose, purity, etc. were studied. High heritability for quality characters like brix and sucrose was found, suggesting that their improvement will have less difficulty. In another experiment with two groups of varieties, genotype × location variance component was found to have comparatively low magnitude with respect to several economic characters. These data suggest that test in large number of locations will not be necessary for various genotypes. They also explain to some extent the fact that selection at Coimbatore for eventual release of varieties in various parts of India has been successful. In these studies in certain groups of varieties, for certain characters no significant genetic variation was found suggesting that improvement of these characters should be carried out by crossing these varieties with varieties from

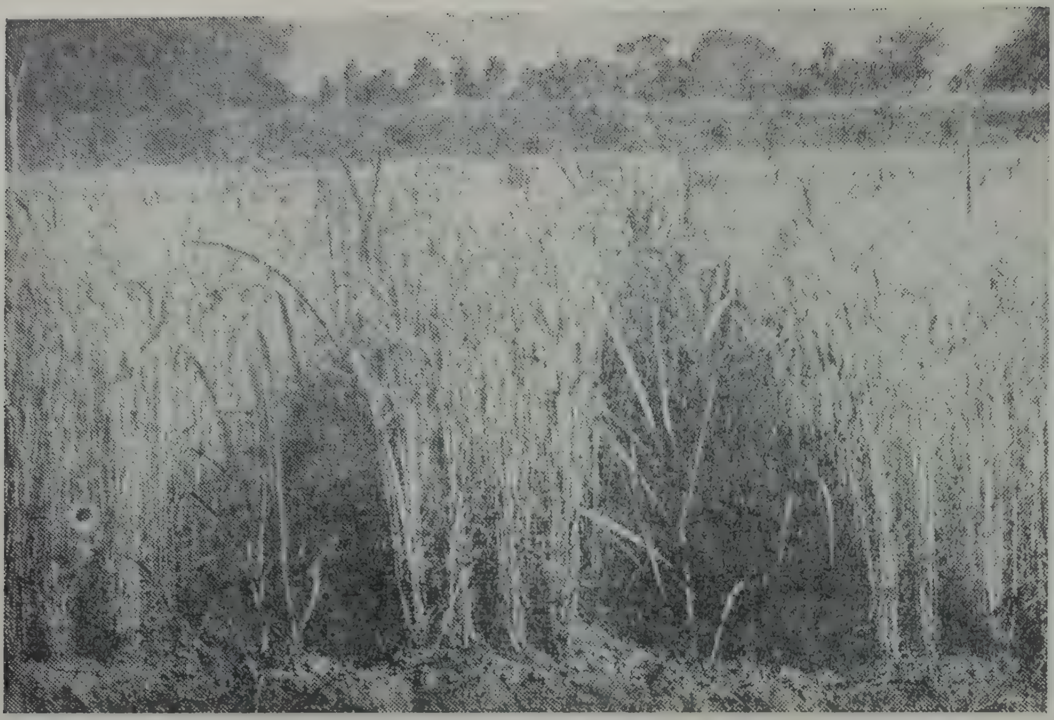


Fig. 1 B

other groups. It is of interest to note that these basic studies have direct applied use in certain cases.

We have started work on intercropping of wheat and sugarcane. From the data available so far, it seems to be an economic proposition. Data given below in Table 2, which were obtained in the year 1970-71, show that in case of both 2 rows (vide Fig. 1A) and 4 rows of wheat intercropped (vide Fig. 1B), there is substantial additional profit.

We are trying various combinations of fertilizer doses and various levels of plant populations to find out most economic combination in wheat and sugarcane intercropping. We have started some work on genetics of disease resistance and a back-crossing programme for incorporating disease resistance. We propose to intensify this work.

Botany

One of the important aspects of this section's work is the collection, maintenance and study of germplasm. The entire collection of around 2,800 genotypes is maintained at Cannanore (Kerala State) sub-station to keep it free from mosaic disease. These include the genotypes belonging to various pure species and the foreign and Indian commercial hybrid varieties. As a result of these studies, several genotypes have been identified and used in improving commercial varieties. More intensives studies are envisaged as has been mentioned earlier. More than 50 foreign commerical varieties are at present being studied in various Centres of India to find out their use from the point of their direct introduction or as breeding material.

With a view to facilitating easy identification of commercial varieties a morphological, anatomical and agronomic description of the varieties has been made. This is of considerable use to factories in identifying varieties, especially where there is a doubt about the purity of the variety.

Varietal trials to identify varieties which will be of commerical use in this general area, have been carried out. In collaboration with Chemistry Section, several early and high-sugared varieties have been identified in these studies. Data with respect to sucrose%juice at 10 months of three of the early high sugared varieties, viz., Co. 6804, Co. 6806 and Co. 6807, as compared to Co. 419 are given on page 42.

The yields of these varieties also are comparable to the standard in the preliminary trial and are being intensively evaluated. The difficulties in introducing these high sugared varieties even though they may give more total sugar per acre though slightly less yield (tonnage) than the existing variety, were discussed recently in a seminar at Sugarcane Breeding Institute, Coimbatore. It was observed here that the best way of solving this

Fig. II

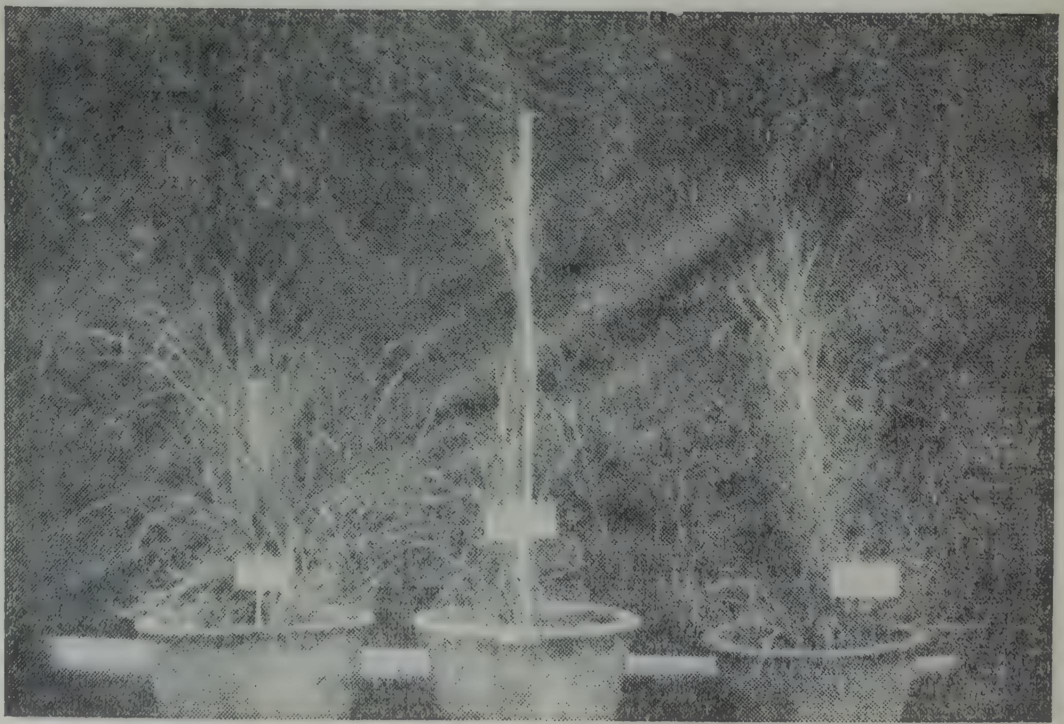


TABLE 1. DATA WITH RESPECT TO MOST WIDELY GROWN VARIETIES IN VARIOUS STATES (65–66 census)

State	*Total area under sugarcane in lac hectares*	*Percentage of total area in the country*	*Reported area under sugarcane in lac hectares*	*Variety*	*Percentage of total reported area*
Uttar Pradesh	14.90	53.59	6.13	Co. 312	20.68
				B.O. 17	14.87
				Co.S. 510	11.30
				B.O. 3	6.80
				Co. 527	5.63
				B.O. 32	3.85
				Co. 313	3.58
				Co. 341	
				Co. 975	
				Co.S. 245	—
				Co. 1148	
				others	
Punjab and Haryana	3.50	12.59	3.50	Co. 312	30.46
				Co. 453	8.53
				Co. L. 9	8.16
				Co. L. 29	5.94
Bihar	1.70	6.11	1.70	B.O. 32	34.22
				B.O. 17	17.38
				B.O. 3	15.57
				B.O. 14	8.83
Maharashtra	1.61	5.78	1.53	Co. 740	59.74
				Co. 419	37.00
				Co. 775	1.71
Andhra Pradesh	1.36	4.88	1.20	Co. 419	62.92
				Co. 527	14.28
				Co. 997	14.08
Tamil Nadu	0.86	3.10	0.86	Co. 419	78.29
				Co. 449	10.05
				Co. 658	8.09
Madhya Pradesh	0.78	2.81	0.68	Co. 312	28.00
				Co. 419	28.00
				Co. 421	16.00
Mysore	0.77	2.77	0.77	Co. 419	80.96
				H.M. 320	2.84
Rajasthan	0.57	2.05	0.57	Co. 312	44.87
				Co. 419	30.06
				Co. 527	2.13
Orissa	0.47	1.67	0.47	Co. 419	42.42
				Co. 881	16.86
				Co. 421	11.46
West Bengal	0.39	1.40	0.39	Co. 527	52.00
				Co. 419	17.00
				Co. 313	4.00
Gujarat	0.35	1.27	0.34	Co. 419	64.70
				Co. 775	11.76
Assam	0.30	1.08	0.06	Co. 419	46.19
				PCJ. 2714	9.84
				Co. 313	5.64
Kerala	0.09	0.33	0.09	Co. 449	57.93
				Co. 419	20.05
				Co. 997	13.48
Pondichery	0.01	0.04	0.01	Co. 658	36.90
				Co. 785	
				Co. 449	
				Co. 41	
				others	

(*Source:* "Census of Sugarcane Varieties in India 1965–66." Directorate of Sugarcane Development, Min. of Agr., New Delhi, 1971).

problem was to give *ad hoc* premium for these varieties, for the extra total sugar per acre.

Inter-cropping of sugarcane with drought tolerant rice varieties, Cauvery and Bala, was carried out. In the first year of the experiment, the data showed higher profit for the inter-cropping treatments as compared to sugarcane alone. More intensive studies on the same line as for wheat-sugarcane inter-cropping have been taken up.

Cytogenetics

An important aspect of work of this section has been the development of the concept of origin of North Indian canes, viz., *S. barberi* and *S. sinense*. Work in this Institute has shown that these two species have most probably originated from hybridisation between *S. officinarum* and *S. spontaneum* in India. Even at present it is the most accepted hypothesis for the origin of North Indian canes. Another important contribution of the Section is the development of pollen grain squash technique which has helped considerably in determining the chromosome number and study of karyotype of various genotypes.

Work has been started on the use of radiation and chemical mutagens to induce mutations which may be of economic importance. A red rot resistant mutant in Co. 997 has been obtained. This mutant is being tried at present in northern part of the country and it has shown fairly good prospects as an early high-sugared variety at our Karnal Sub-station. Red rot resistant mutants have also been obtained in Co. 449, Co. 527 and Co. 312. A red rot resistant mutant of Co. 449 was sent to States as Co. cane for further testing.

As regards future work is concerned, we are planning to concentrate more on use of radiation and chemical mutagens as tools for obtaining desirable mutants in the existing commerical varieties.

TABLE 2. SUGARCANE-WHEAT INTERCROPPING (ECONOMICS)

	Cane yield per acre (tons)	*Wheat yield per acre (Kg.)*	*Gross return in Rs./acre*	*Net extra return in Rs./acre—as compared to cane alone*
T_1 Sugarcane alone	35·54	—	—	—
T_2 Wheat alone	—	1164.80	—	—
T_3 2 rows + cane	34·33	560.20	3290.00	397·00
T_4 3 rows + cane	31.65	636.65	3165.00	265.00
T_5 4 rows + cane	32.15	683.95	3337·00	405.00

SUCROSE % JUICE AT 10 MONTHS OF 3 HIGH SUGARED VARIETIES

Co. 6804		Co. 6806		Co. 6807		Co. 419	
1970–71	1971–72	1970–71	1971–72	1970–71	1971–72	1970–71	1971–72
21.07	21.17	18.56	18.12	20.82	21.10	15.92	16.19

EFFECT OF DIFFERENT MICRONUTRIENT SPRAYS ON THE RECOVERY OF CHLOROTIC PLANTS IN THE VARIETY Co.419.*

No.	*Micronutrient*	*% chlorotic shoots observed/row*	
		Before spray	*15 days after spray*
1.	Control (water spray), Sulphur treatment and manganese treatment	47·3 to 56.4	58.8 to 66.6
2.	Iron as chelate at 1 kg/ha.	53·9	2.1
3.	Iron as Ferrous sulphate at 1kg/ha.	43·7	0.9

*Formation of chlorophyll bundles in leaves was taken as the criteria for recovery.

Basic studies to improve their efficiency will be more intensified.

Chemistry

Various studies have been carried out to find out association of certain bio-chemical characteristics with economic characters such as yield, earliness vs. lateness, red rot resistance, etc. Study of iron-chlorophyll balance in leaves at 5 to 6 months age appears to be of use in forecasting early and late maturing nature in sugarcane varieties. Cation exchange capacity (CEC) of roots and yield in preliminary experiments showed association. To find out how strong is this association and whether this association is different in different locations, experiments are underway. Phenolic content has shown some association with red rot resistance. The magnitude of this association is also being studied.

Pathology

One of the important aspects of the work of this section is the standardisation of techniques for testing for disease resistance. Techniques have been standardised for testing against major diseases like red rot, and smut by artificial method. These techniques are of considerable use in evaluating genotypes in segregating generation for their disease resistance.

In case of seedling root rot in the seedling flats, 0.1% ceresan wet or 1% bordeaux mixture was found effective. In certain varieties, treatment of setts with 1000 ppm of 2-thiouracil was found effective against mosaic virus. This technique is of considerable use to free the material of mosaic to send it outside.

High sugar forms in various species of *Saccharum* were selected and they were studied with respect to resistance to red rot and smut diseases. Among these forms one genotype in *S. officinarum* with resistence to red rot and five genotypes in *S. spontaneum* with resistance to both red rot and smut were identified. These genotypes are of interest from the breeding point of view. A genotype with high resistance to mosaic has also been identified.

We are planning to standardise techniques for testing for various diseases which may give us more strong association with the field performance of these varieties. The germplasm also will be more intensively studied for combination of desirable characters including disease resistance, so that this information could be directly used for breeding.

Entomology

Evaluation of pest resistance was done in terms of per cent incidence under natural infestation in germplasm and other genotypes. Four varietes were found to be relatively resistant to top borer, 49 to shoot borer and 22 to internode borer. The progenies from varieties Co. 449, Co. 527 and Co. 798 had shown resistance for internode borer.

Chemical control measure (0.04%

Folidol spray) has been worked out for scale insect.

We are planning to start breeding for insect resistance. The major difficulty in carrying out this work is the absence of suitable techniques for artificially raising the insects. We are planning to intensify these studies.

Physiology

One of the important contributions of this section is to control flowering in sugarcane. This is of considerable importance because many of the varieties which could be used in breeding to impart economic characters to the progeny do not flower. Also in some cases two varieties to be used in crossing do not synchronise in their flowering. By giving various dark and light treatments, the varieties have been either made to flower or made to synchronise in their flowering (vide Fig. II; left control, middle 4 hours extra dark treatment, right 4 hours extra light treatment). Four hours extra dark treatment induces flowering in non-flowering varieties while 4 hours extra light treatment suppresses flowering. In case of synchronisation, the early flowering varieties are given 4 hours extra light for 15 days and then 4 hours extra dark treatment. In case of late varieties, the treatment given is 4 hours extra dark treatment to make them to flower early. By the above treatments, in number of Co. canes and other hybrid canes and some genotypes of *S. officinarum*, *S. spontaneum*, *S. barberi* and *S. robustum* flowering was controlled. The examples of these hybrid canes are Co. 290, Co. 798, Co. 281, Co. 508, POJ. 2725, B. 37172 and others.

Yellowing of top leaves has been observed in and around Coimbatore. Detailed chemical analysis showed that chlorotic leaves contained less of iron (58% lower) when compared to healthy leaves. The spray applications of nutrients like sulphur, manganese chelate, iron chelate, etc. have shown that only iron compounds help the plant to recover as could be seen tabulated on page 42

Studies on drought resistance have been taken up for a group of varieties. The drought was given at the tillering phase for a period of 90 days, starting from 60th day from planting. It was found in these preliminary studies that varieties differ in the reduction in sucrose content under drought conditions. A similar differential response with respect to yield was not observed. More intensive studies are proposed to substantiate these findings.

As regards future work is concerned, it is proposed to study more intensively problems associated with breeding for drought resistance, frost resistance and other related problems. We are planning to find out correlations of characters, which could be easily assessed at early stage in the selection programme, with resistance to drought and frost.

P.L. 480 Projects

In the first P.L. 480 Project in this Institute, started in 1963, 55 American varieties were supplied by the United States Department of Agriculture. These were crossed with *S. spontaneum* genotypes. The progenies were screened for resistance to mosaic, red rot, rust, smut, ratoon stunting disease (RSD), cold and drought, and for agronomic characters for selection of hardy, disease resistant basic stocks. As a result of these studies 85 elite I.A. clones were selected which had the various desirable characters. These elite I.A. clones are at present being evaluated for various economic characters to use them for breeding programme.

At present work on a 2nd P.L. 480 programme is going on at this Institute. The main objective of this P.L. 480 programme is to cross Hawaiian, Puerto Rican and Indian sugarcane varieties with *S. spontaneum* genotypes to transmit disease resistance, drought resistance, etc. Till now 52 elite I.A. clones have been selected and these possess over and above desirable agronomic characters, resistance to diseases such as mosaic, smut and RSD. They have also been screened for drought resistance.

Co-ordinated Project

Some of the experiments mentioned earlier, viz., supply of fluff to different centres, CEC and yield correlation, association of drought resistance with various morphological characters, etc., are part of the Co-ordinated Project. Over and above these, other important experiments which are being studied are: zonal verietal trail where promising varieties in various States in the zone concerned are being tried to see whether these varieties have wider adaptability than in the State concerned, effect of certain management practices on the performance of sugarcane ratoons, etc. In the zonal varietal trial the newer variety Co. 6304 has given better performance (higher yield) than Co 62175, Co. 658 and I.C. 225.

Acknowledgment. Help of some of my colleagues in the Institute in compiling the research work in the various sections is gratefully acknowledged.

Reference. Allard, R. W. & Bradshaw, A.D. (1964). Implications of genotype-environmental interactions in applied plant breeding. *Crop Sci.*, **4**: 503-8.

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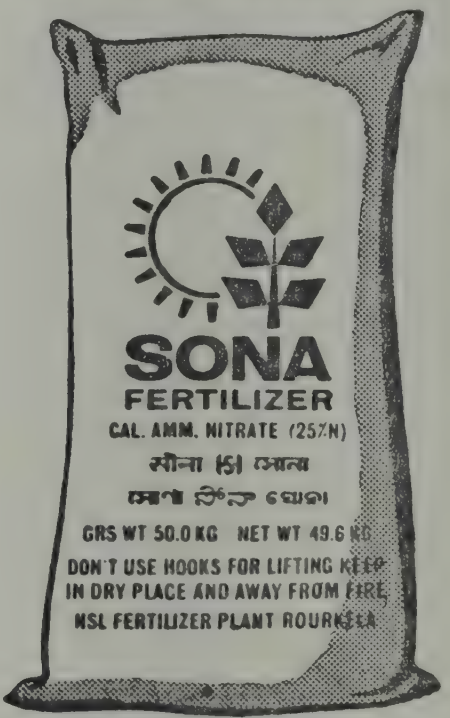
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ACHIEVEMENTS OF TOBACCO RESEARCH IN INDIA

N.C. GOPALACHARI
Officiating Director, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh

PROBLEMS of practical importance have been tackled at the Central Tobacco Research Institute, Rajahmundry, and at the Tobacco Research Stations, Dinhata, Guntur, Hunsur, Pusa and Vedasandur in several short-term and long-term projects over the past two decades on cigarette, *natu, lanka, hookah,*chewing, cheroot, cigar-filler and cigar- wrapper tobaccos and the salient findings are presented below.

Details pertaining to the selection of nursery site, lay-out, manuring, seed-rate, method of sowing, care of nursery beds after sowing, top-dressing, etc., have been worked out after intensive research over a number of years. Farmers who in the past were obtaining their seedlings from far off places for planting them in their fields are now confidently raising their seedlings in their own seed beds. In addition, a number of commercial nurseries have cropped up in Andhra Pradesh after acquiring the know-how from the Central Institute. Pure and clean seed of improved strains of flue-cured Virginia, *lanka, natu* and burley tobaccos approved for cultivation and tested for its viability, is distributed by the Central Institute and its Regional Station at Guntur through the Extension Department of the State Agricultural Department, Andhra Pradesh.

The optimum time of sowing the nursery is found to be the second fortnight of August and seed rate of 2-3 kg per hectare is found to be sufficient.

The following improved practices have been recommended for raising successful nursery:—

(1) Pre-soaking of the seed in 50 ppm gibberellic acid solution for 48 hours for improving the germination and transplantable seedlings even under unfavourable seasonal conditions i.e., prevalence of high temperature during the nursery season.

(2) Spreading tobacco midribs at the rate of 5 tonnes/ha over the beds for protecting the seed beds against scorching sun and beating rains.

(3) Application of a basal dressing of 50 kg ammonium sulphate, 300 kg of superphosphate and 100 kg of dolomite and a top dressing of 100 kg of calcium ammonium nitrate per hectare of nursery.

The beneficial effects of superphosphate were clearly demonstrated especially in black soil nurseries.

Application of left over ash of cattle dung cake at 35 tonnes/hectare, because of its richness in phosphorus and potash, was found to be equally effective.

Studies pertaining to the various field operations resulted in a package of practices most suitable for getting the maximum benefit in terms of yields and quality of leaf.

With a view to increasing the yield per unit area and unit time and also the monetary returns of the farmers, a number of crop rotational practices have been tried and the suitable ones for the different tracts are recommended. The practice of growing dry paddy in strips in kharif followed by f.c.v. tobacco in rabi has been found to be most suitable for Krishna, East and West Godavari districts. Similarly growing gingely in the kharif followed by tobacco in the rabi is most suitable for Guntur and Ongole districts.

Vigorous propaganda is being made through Press, Radio talks in the Villagers' Programme and through the Extension Staff regarding the use of only approved pesticides at the recommended doses for tobacco. The pesticides that are not to be used on tobacco under any circumstances are: 1) Endrin, 2) Lindane, 3), Toxaphen, 4) Aldrin, 5) Dieldrin, 6) D.D.T., 7) Parathion dust, ex-Folidol dust, Paramer dust, etc., 8) Heptachlor and 9) Chlordane which are all chlorinated hydrocarbon compounds.

About 25 per cent of the cost of production of F.C.V. tobacco is due to the curing process, so essential for obtaining bright leaf. Efficient utilisation of the heat from the fuel may lead to an economy in the curing process. For this purpose an improved barn with more efficient arrangement of flues, bottom ventilators and top ventilators was designed, constructed and advocated to the farmers. An improved curing schedule which saves time and reduces the cost of curing was also formulated and the farmers informed of its advantages. It was recently found at the Central Institute that paddy husk may be used as fuel in barns for which a suitable furnace is designed. In locations where paddy husk is available in large quantities at prices not exceeding 57 paise per bag the farmers will be profited by using it in place of coal or wood, with practically no difference in cured leaf and bright grade returns from the same quantity of green leaf loaded.

Cigar ('Vellavazhai') tobacco crop

Detailed investigations on the objective assessment of quality in F.C.V. tobacco resulted in arriving at certain chemical ratios such as Schmuk Number, Kovalenko Coefficient and reducing sugars/nicotine as reliable yardsticks for measurement of smoking quality. Physical quality characters which determine the manufacturing economy are found to be associated with filling value, porosity, equilibrium moisture content, leaf strength, leaf-elasticity and shatterability. For both chemical and physical quality characters, acceptable ranges for their values have been determined and quality of tobacco produced is being assessed. These measures are also being applied in assessing the quality of Indian flue-cured tobacco in comparison with American and Rhodesian tobaccos for effecting further improvement through genetic and cultural techniques. On the basis of the extensive work done at the Central Institute, grading the cured leaf according to its position on the plant is advocated.

Quality was found to be influenced by the stage of maturity of leaf at harvest and leaf harvested at the correct stage of maturity gave the best quality leaf. A test paper technique which is quite simple and can be followed easily by farmers has been developed.

Dark green grades of tobacco which are practically worthless could be improved to light medium green grades by heat treatment under humid conditions whereby the value is enhanced six times in terms of price.

Low nicotine cigarettes could be made from tobaccos treated with hydrogen peroxide since it involves chemical oxidation of the alkaloid as well as increase in the specific volume of the tobacco shreds.

Tobacco produced in lowlying and saline areas deteriorates in quality during storage, becomes muddy brown in colour on storage and does not burn properly. After a detailed survey and study of the soil and plant samples the reason was found to be the high chloride content of the soil as in saline areas or of the groundwater as in low-lying areas, resulting in high chloride uptake by the plant.

Chewing ('Monnai') tobacco crop

While an intensive propaganda was made to discourage farmers from growing tobacco in low-lying and saline areas, an electrotitrimetric method for determination of chloride content of leaf was developed and demonstrated to the Marketing Department, and it is now widely adopted by the Agricultural Marketing Department to demarcate 'saline' tobacco.

Pesticide residues have been recognised as a potential problem by the tobacco industry all over the world in view of their impact on the health of the smoker. Continuous quality surveillance for timely detection of pesticide residues beyond tolerance limits is essential for prompt action and promotion of the export potential of Indian tobacco. Setting up of a Pesticide Residue Laboratory at the Central Institute is being finalised and work is going to be initiated shortly on this important problem.

Detailed studies on the water-requirement of the tobacco crop are initiated in the light soil areas and these may help in evolving dependable irrigation schedule for the crop.

In view of the indiscriminate irrigation of tobacco crop in Nagarjuna Sagar areas by the farmers, a scheme has been initiated to study the effect of irrigation in soils of different textural classes in these areas on the quality of the leaf.

With the increased awareness of the association of cigarette smoking and lung cancer, it is necessary to determine the carcinogenic potentialities of Indian flue-cured tobacco as information on this aspect is lacking. The three major means of reducing the carcinogenic properties viz., tobacco selection, chemical additives and physical processing techniques will be exploited.

In view of the demand for low nicotine tobacco by the importing countries this aim will be achieved by combining the genetic and agronomical factors conducive to lower nicotine content in the leaf. A package of practices involving the inherently low nicotine producing varieties, suitable plant population, manuring schedules, level of topping, etc., will be evolved.

In the fields of pest and disease control, testing of easily available indigenous products for control of major pests, biological control of important pests in collaboration with Commonwealth Institute of Biological Control, Bangalore, screening of varieties resistant to various diseases and pests and survey of tobacco growing areas for the incidence of various pests and diseases and the extent of the damage caused are some of the immediate problems engaging the attention of the scientists at this Institute.

Other Types Of Tobacco

Natu Tobacco. Natu tobacco grown in Andhra Pradesh in an area of about 59,000 hectares comprises a group of local varieties of *N. tabacum* and is used principally in local cheroots and cheap cigarettes. This tobacco is also used to a small extent as snuff, pipe, chewing and shag tobacco.

There are two main distinct types among *natu*, one which is grown in black clayey soils of Guntur, Ongole, Mahaboobnagar, Nalgonda and Kurnool districts under rainfed conditions and the other grown in red sandy loams of Krishna, West Godavari and Khammam districts under irrigation and heavy fertilization. The former, grown in about 28,000 hectares, is used in cheroots and cheap cigarettes and the latter, grown in about 15,000 hectares, is used for cheroots and snuff. Work done at the Tobacco Research Station, Guntur, pertains only to the former.

Jati (topped) tobacco crop

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Two improved strains viz., DG-3 and DG-4 evolved at Guntur Station have proved superior to locally grown *Natu* varieties, giving about 30 per cent more yield in the district trials and will be released shortly to the cultivators. Planting from the middle of October to first week of November at 90 cm ×90 cm spacing, application of 40 kg N/ha as groundnut cake, topping the plant at flower head instead of about 14 leaves as farmers do and harvesting the leaf by priming instead of the stalk-cut method practised by the farmers improved the yield and leaf quality substantially so as to give a higher net income of about Rs 425 per hectare.

Cheroot Tobacco. *Lanka* tobacco, another distinct type of tobacco, grown on the islands and banks of the rivers Godavari and Krishna is used exclusively for cheroots (*Chuttas*). A selection DR.1 isolated for its higher yield and superior quality over the existing varieties was given to the cultivators and has almost saturated the whole *lanka* tobacco growing area of Andhra Pradesh. The major problem in *lanka* cultivation is the severe aphid incidence. The aphicides recommended for F.C.V. tobacco work well on *lanka* tobacco also, but more number of sprayings are required as the aphid incidence is high. Recently, the granular type systemic aphicides such as Solvirex and Phoratew ere tried and found to give excellent control for a much longer duration.

In Tamil Nadu the principal variety of cheroot tobacco grown in about 800 hectares, is *Oosikappal.* The selections evolved in *Oosikappal* (local) at the Vedasandur Research Station are OK-1 (broad leaf type) and I-737 (narrow leaf type). Further improvement in I-737, by crossing it with Olor-10 has been achieved at the Station.

Cigar Filler Tobacco. Cigar filler tobacco occupies hardly 120 ha in Madurai and Tiruchiraipalli districts of Tamil Nadu and presently about 6 ha in Cooch-Behar district of West Bengal.

At Vedasandur, superior selections have been evolved from the local varieties *Vellaivazhai* and *Karuvazhai* and they are VV-2 in the former and KV-1, I-452 and I-462 in the latter. These selections have almost saturated the cigar filler growing areas. Credit goes to the Station for acclimatising the exotic Puertorican Cigar filler variety Olor and evolving a superior selection Olor-10, out of it. The exotic variety Havana-142 has also been found superior. A package of practices comprising application of 75 kg N+50 kg P_2O_5/ha, spacing of 75 cm×75 cm and topping at 14-16 leaves for local varieties and 18-20 for Olor was recommended for adoption.

Work done at the Dinhata Station (West Bengal) showed that varieties Swarr Hibshman, I-452, Havana-381 and Olor-10 are suitable to the tract. Spacing of 90 cm×50 cm planting in mid-October to 1st week of November, topping at 14-16 leaves (for Olor 18-20 leaves), application of 150 kg N, 100 kg P_2O_5 and 100 kg K_2O/ha were recommended for adoption.

The cigar filler tobacco produced in the above areas is found to be of good quality and is having good export potential based on the favourable opinions expressed by some foreign firms. Internal demands are also fast increasing for this tobacco and its acreage may increase considerably in the next few years as it is finding an additional use for blending in cigarettes.

Cigar Wrapper Tobacco. Exploratory trials started at Dinhata Tobacco Research Station in an area of 6 hectares in Cooch-Behar district of West Bengal proved that good quality cigar wrapper tobacco can be produced in that tract. Internal demand is fast increasing and the crop may get established in a larger area in the next few years.

Variety Dixie Shade was found to be the best for this tract. Spacing of 75 cm×45 cm planting from mid-October to first week of November, application of 125 kg N, 112 kg P_2O_5 and 224 kg K_2O/ha harvesting in 4-5 primings and air-curing in *Kutcha* barn, bulking and grading according to size of leaf were recommended for adoption.

Chewing Tobacco. Chewing tobacco is an important cash crop of Bihar, Uttar Pradesh, West Bengal and Tamil Nadu. Work carried out at Vedasandur Research Station, Tamil Nadu, resulted in the recommendation of the following varieties suitable to the different tracts of the region:—

	Area	*Variety*
1.	Monnai	I-64
2.	Smoke-cured area	PV-7
3.	Vedaranyam	VR-2
4.	Meenampalayam	I-115
5.	Vattakappal	VTK-1
6.	Vadamugam	VD-1
7.	Sivapuri	S-1

A spacing of 75 cm×75 cm., planting in November to December is a staggered system, topping at the level of 7-9 leaves, application of 25 tonnes of F.Y.M., 100 kg N and 50 kg P_2O_5/ha are in the package of practices evolved at Vedasandur Research Station for Chewing tobacco of Tamil Nadu.

At Pusa Research Station, three hybrid selections viz., HP 6-11, HP. 6-18 and HP.6-20 were found superior to the existing DP. 401 evolved earlier, in trials conducted at the Station as well as in the districts and are likely to replace the existing one in the coming years. Application of 168 kg. N/ha as ammonium sulphate and mustard cake, spacing of 90 cm×60 cm planting by the end of September topping at 14 leaves, piercing the stem afer topping, adopting a multiple cropping pattern of maize in kharif, tobacco in rabi and maize in summer, doubled the net returns over tobacco alone. Inter-cropping with green onion brought an increased net return of Rs 400 per hectare.

Hookah Tobacco. Tobacco grown for Hookah belongs to the species *N. rustica* and *N. tabucam*. Among the former, *Motihari* (West Bengal), *Vilayati* (Bihar), *Calcuttia* (Uttar Pradesh and Punjab) and *Gobhi* (Punjab) are the types grown commonly. The types grown under the latter species are called *desi* in Bihar and *Jati* in West Bengal.

The package of practices evolved at the Dinhata Research Station for *Motihari* (Variety Hemti) recommend application of 12.5 tonnes of F.Y.M./ha a fortnight prior to transplanting, *plus* application of ammonium sulphate at 112 kg N/ha before transplanting in the first week of November at 60 cm × 45 cm spacing, topping at 8 leaves, priming, sun-drying for 8-10 hours, bundling, air-curing in *Kutcha* barns for 4-5 weeks preparing hands (*peti*), bulking and grading.

A new intensive cropping pattern with Aus paddy—Aman paddy *Motihari* tobacco rotation was established by the Dinhata Research Station, giving an additional net income of Rs 2,700 per hectare over Aus paddy—*Motihari* Tobacco rotation followed by the farmers of West Bengal.

For *Jati* tobacco, varieties *Chama* (late maturing) or *Podali* (early maturing) can be grown with 100 kg N/ha, planting from middle to end of October at 90 cm × 90 cm spacing, topping at 8 leaves, priming 3-4 times and adopting procedures similar to that of *Motihari* for curing and grading, with the exception of soaking the petioles and leaves in water during preparation of *Peti*.

Selections T-17, 31-37 and 33-32 in *Motihari* and selections DD-413, DD-414, DD-415 and DD-417 in *Jati* proved to be superior to the existing varieties at the Research Station and in district trials at six centres. They will be recommended to be released for cultivation by the farmers.

Bidi Tobacco. Research on various aspects of *bidi* tobacco production is being carried out at the Bidi Tobacco Research Station, Anand. The research work so far undertaken has resulted in evolving 3 improved varieties, viz. Anand-2, Anand-23 and Anand 119 yielding 31%, 26% and 26% higher yield respectively over K-20. The optimum requirement of N for the tobacco was found to be 160 kg per hectare applied wholly as oilcake or partly as oilcake and partly as chemical fertilizer and this together with planning at 0.88 m × 0.88 m and topping at about 11 leaves produced good quality and higher return to the farmer. For the control of nematodes in the nursery, Nemagon at 50 litres/ha and Shell DD at 560 litres/ha were found to be quite effective. From the point of cost, Nemagon at Rs 760/ ha was cheaper than Shell DD at Rs 2,800/ha.

Coordinated Project on Tobacco

Under the Project, initiated in the year 1970, work on exportable types of tobacco viz. cigarette, *natu*, Burley, cigar filler, wrapper and *bidi* tobacco is being carried out at the main centres Rajahmundry, Pusa and the Agricultural University, Bangalore and the Bidi Tobacco Research Station, Anand and at the sub-centres Guntur, Hunsur, Dinhata and Nipani. The work so far carried out has given valuable information on the applicability of the various research findings of the Central Institute and the Research Stations on a wide range of representative tobacco growing tracts of India.

The search continues for finding out the most suitable varieties for the various agro-climatic tobacco growing tracts and their optimum requirement of fertilizers and cultural practices, under constant surveilance of pesticide residues and quality of leaf.

Demonstrations and Extension

The research findings emanating from the Central Institute and the five Research Stations at Guntur, Vedasandur, Pusa, Dinhata and Hunsur are put under trials in the farmers' fields to find out their large-scale utility and adoptability. National Demonstration trials to show the superiority of paddy in strips—tobacco rotation over Fallow—Tobacco practised by farmers is conducted at four locations in the northern tobacco growing districts of Andhra Pradesh. Similarly Rotation Trials with Gingely-Tobacco rotation in comparison with Fallow-Tobacco is being conducted at four locations in the southern districts of Andhra Pradesh.

Advanced breeding lines with proven superiority over the existing standard varieties in quality and yield are put under location trials for 3 consecutive years, before recommending to the Variety Release Committee. Thus, at present four improved selections are put under location trials at four locations. Similarly, the newly evolved *natu* varieties DG-3 and DG-4 of Guntur Research Station, improved Cigar-filler and Chewing selections of Vedasandur Research Station and improved *Jati* and *Motihari* selections of Dinhata Research Station are under location trials. Besides, the package of practices evolved at the Central Institute for Cigarette tobacco are under District Trials.

There is a Demonstration Section at the Central Institute with one Demonstration Assistant who is working in close cooperation with the Tobacco Extension staff of the Andhra Pradesh Agricultural Department particularly in laying out demonstration trials on cultivators' fields. Advisory service to the tobacco growers in the different stages of tobacco production, publicity and propaganda activities by publication of leaflets, participation in exhibition holding farmers' week, conducting demonstration trials on cultivators' fields, etc., are the main activities of the section. A total of 528 demonstration trials were conducted during the past two decades and 38 leaflets in Telugu and 54 leaflets in English, were published mostly in flue-cured tobacco

A film on 'Virginia Tobacco' was produced at the Institute during 1961-62 and it is being screened since then at all cultivators' gatherings.

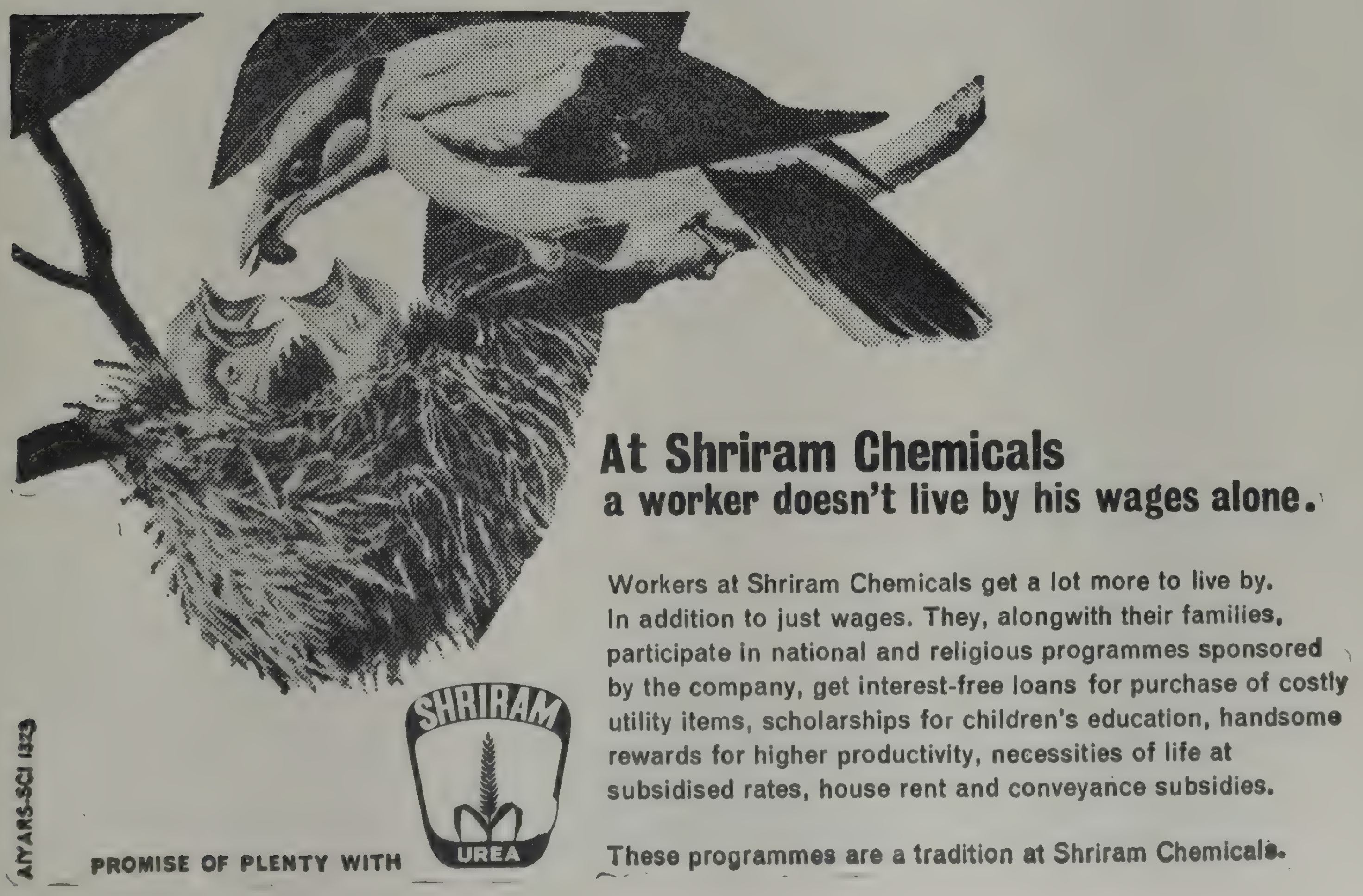
An Extension Wing is going to be attached to the Central Institute and also to the Guntur Research Station under the Forth-Five Year Plan which may fulfil the long-felt need in establishing more direct contact with the farmers and taking the research findings to the door step of the farmers without losing any time.

Development Scheme

Under the aegis of the Indian Tobacco Development Council, many development schemes are functioning. Among them the important one is the scheme for the production and distribution of pure seed and seedlings functioning at Rajahmundry, Vedasandur, Hunsur and Dinhata. The Instiute is annually producing and distributing about 11,000 kg of pure seed of approved varieties to the growers through the agency of State Extension Staff.

The other development schemes functioning at Dinhata are: (1) Scheme for training in the improved methods of tobacco cultivation, harvesting and handling of the cured leaf and (2) Scheme for exploratory trials on cigar filler tobacco.

Besides the above mentioned development schemes a centrally sponsored scheme for extending cultivation of Cigar Wrapper tobacco in farmers' fileds is in operation at Dinhata.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Project Coordinator I.C.A.R., Central Soil
Salinity Research Institute, Karnal

THE practice of irrigation in India is perhaps as old as the very art of agriculture, but water management research remained a neglected field and lagged much behind the rapid development of science and technology in other branches of agriculture. In the past irrigation supply used to be revenue-oriented and not production-oriented, with the result that the output per unit of water was very low. About 60% of irrigation water is lost by various means before it reaches the farmers' fields. A typical example of colossal wastage of water is the land submergence practice in rice cultivation, which results in huge percolation loss being far greater than the combined loss through evaporation and transpiration. The faulty use of irrigation water instead of being a boon became a curse by creating serious problems of waterlogging, soil salinity and low productivity in many areas. Besides, suitable methods for using brackish water for irrigation without any detrimental effects on soil and crop have to be developed in areas where there is no other alternative source available. Efficient use of irrigation water based on the results of an integrated research programme on water management is, therefore, equally or sometimes even more important than the other inputs like improved seeds, balanced fertilizers, pesticides and other agronomic practices for achieving increased crop production. This has become all the more necessary to obtain full production potential of the high-yielding varieties in the present drive of green revolution.

Considering the importance and urgency of integrated research on water management, the Indian Council of Agricultural Research started a co-ordinated research project for research on water management and salinity at sixteen centres located in different agro-climatic regions of the country namely, (1) College of Agriculture, Indore (M.P.), (2) U.P. Institute of Agricultural Sciences, Kanpur, (3) Saline Research Sub-Station, Canning Town (West Bengal), (4) Punjab Agricultural University, Ludhiana, (5) Indian Agricultural Research Institute, New Delhi, (6) S.K.N. College of Agriculture, Jodhpur (Rajasthan), (7) Irrigation Research Institute, Roorkee (U.P.), (8) Irrigation Research Station, Bikramganj (Bihar), (9) Indian Institute of Technology, Kharagpur (West Bengal), (10) Assam Agricultural University, Jorhat, (11) A.P. Agricultural University, Hyderabad, (12) Tamil Nadu Agricultural University, Coimbatore, (13) Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), (14) Haryana Agricultural University, Hissar, (15) Irrigation Research Station, Chakuli (Orissa) and (16) Irrigation Research Station, Siruguppa (Mysore) besides the Central Soil Salinity Research Institute, Karnal where the Project Coordinator of the Scheme is located.

Water management and scheduling irrigation

There has been a continuous advancement in the concept for determining water requirements of crops and scheduling irrigation. In the beginning, transpiration ratio was taken as water requirement of crops and was used for planning irrigation. Subsequently, the depths and intervals of irrigation were fixed arbitrarily and the treatment, which produced maximum yield with minimum quantity of water, was considered as optimum irrigation requirement of a given crop. For instance, the optimum interval of irrigation for potato (Bihar and Punjab) groundnut (Tamil Nadu) and onion (Bihar) was found to be 6-9 days, 10 days and 7 days, respectively. Both these concepts had limited applicability, as they led to excessive, deficient, early or late irrigation in different cases, though considerable data on many crops was collected.

Greater attention was then paid to the soil moisture regime concept, in which a measured quantity of water sufficient to fill the soil moisture deficit at a definite moisture stress is applied. Experiments have further been conducted to evaluate the different critical growth stages of crops, when adequate supply of water is very essential. In recent years, climatological approach has also received considerable attention

TABLE 1. EFFECTS OF DEPTHS OF SUBMERGENCE ON GRAIN YIELD (q/ha) OF RICE IR.8 AT KHARAGPUR

Depth of submergence	*Monsoon*		*Summer*	
	1970	1971	1970	1971
Saturation	43·8	39·3	33·0	34·0
Shallow submergence (5±2 cm)	40·0	43·2	52·2	51·5
Deeper submergence (10±2 cm)	38·7	45·0	50·0	40·1
L.S.D. at 5%	N.S.	N.S.		8·5

TABLE 2. VARIOUS COMPONENTS OF WATER LOSS UNDER RICE IR.8 AT KHARAGPUR.

Crop	*Depth of submergence*	*Evaporation (mm)*	*Transpiration (mm)*	*Percolation (mm)*
Monsoon	Shallow	150	193	923
	Deep	149	199	1698
Summer	Shallow	395	363	1120
	Deep	401	369	1838

TABLE 3. EFFECT OF DIFFERENT MOISTURE LEVELS ON GRAIN YIELD AND WATER REQUIREMENT OF RICE IR.8 IN KHARIF AT SIRUGUPPA

Moisture levels	*1970*		*1971*	
	Grain yield q/ha	*Water applied (mm)*	*Grain yield q/ha*	*Water applied (mm)*
5–0 cm submergence	57·1	1538	42·7	1190
Saturation to haircracking	54·7	913	44·6	870
Saturation to field capacity	53·6	831	44·6	754

TABLE 4. CRITICAL GROWTH STAGE OF RICE FOR MOISTURE STRESS

Moisture stress at	*Grain yield (q/ha)*		
		Siruguppa	
	Chakuli variety Ptb 10	*Kharif variety IR-8, TNI & CEB*	*Summer variety Kichdi, TNI & S317*
1. Transplanting to tillering	26.8	55·2	41·6
2. Tillering to flowering	20.8	56·4	35·9
3. Flowering to harvest	20.5	54·4	41·6
4. No stress at any stage (5cm submergence)	25.6	55·5	44·0
C.D. at 5%		N.S.	5·7

of the research workers, as the consumptive use by a crop is governed chiefly by the climatic elements if there is adequate plant cover and soil moisture supply is not a limiting factor.

Rice. The results of a recent study made at Kharagpur on a lateritic soil (Table 1) show that submergence between 5 cm and 10 cm did not produce any significant difference in yield and therefore, submergence up to 5 cm only was considered economical. Similar results were obtained at Chakuli (Orissa), Siruguppa (Mysore) and Roorkee (U.P.). In monsoon season, soil moisture regime at saturation produced almost as much yield as submergence treatment but proved much inferior in summer. The data on different components of water loss estimated by drum culture technique in a lateritic soil at Kharagpur reveal that the loss of water through percolation is far greater than the combined loss through evaporation and transpiration and this increases with the depth of submergence in both seasons (Table 2). Thus, a huge quantity of water is lost through percolation under land submergence practice, which is in common vogue in rice cultivation in India and there is a great scope for saving water by growing rice crop on impermeable soils or by using other management practices to create an impervious layer. In a heavy black soil (50% clay) with a relatively high water table at Siruguppa, maintenance of soil moisture from saturation to haircracking in kharif saved about 40% water within a very small loss in yield as compared to 5 cm submergence and, therefore, such practice is considered advantageous in the areas of limited water supply (Table 3). Nitrogen application significantly improved the water use efficiency.

Subsequent studies conducted at Siruguppa and Chakuli revealed that tillering to flowering is the most critical stage when rice crop should not be subjected to any moisture stress (Table 4). Moisture stress from transplanting to tillering followed by submergence (5 cm) proved as efficient as continuous submergence and therefore, continuous submergence of even 5 cm water is not necessary. The results of the study on the effect of varying moisture levels at different growth stages on the yield of rice IR-8 during kharif 1971 at Kharagpur further indicated that submergence (5±2 cm) only at active vegetative and

TABLE 5. INTERACTION OF SOIL MOISTURE REGIME AND FERTILIZER APPLICATION IN RELATION TO KALYAN SONA WHEAT AT INDORE

Irrigation at	*Total water applied (mm)*	*Grain yield (q/ha)*	
		Lower fertility level (60:40:30)	*Higher fertility level* (120:80:30)
1. Crown root initiation	75	19.6	20.6
2. 25% depletion of available water	525	39.5	52.4
3. 50% depletion of available water	600	35.4	48.1
4. 75% depletion of available water	525	31.9	40.6
5. 100% depletion of available water	550	33.0	39.4

C.D. for overall moisture at 5%—3.0 q/ha
D.D. for overall fertilizer at 5%—1.9 q/ha
C.D. for fertilizer at some moisture level at 5%—4.25 q/ha

TABLE 6. SCHEDULING IRRIGATION TO KALYAN SONA WHEAT BASED ON OPEN PAN EVAPORATION AT LUDHIANA

Treatment Irrigation water/PE ratio	*Irrigation water applied (mm)*		*Grain yield q/ha*	
	1969-70	1970-71	1969-70	1970-71
T_1–1.0 throughout	420	360	47.9	41.2
T_2–0.75 throughout	360	300	46.5	38.0
T_3–0.5 throughout	240	180	40.5	36.5
T_4–0.5 up to Mid-Feb. and 0.75 thereafter	300	240	41.2	32.5
T_5–0.5 up to Mid-Feb. and 1.0 thereafter	360	280	41.6	35.0
T_6–1.0 up to Mid-Feb. and 0.5 thereafter	—	240	—	37.4
L.S.D. at 5%			4.5	3.1

reproductive phases produced the maximum yield and resulted in almost highest water use efficiency. Thus, rice can be grown with less amount of water by the use of this practice without any decrease in yield.

Wheat. Being a crop of economic value in rabi, wheat has received greater attention for research on its water requirement, particularly in northern India, crown root initiation, joining flowering and grain formation have been found to be the critical growth stages, when adequate supply of water is essential for increasing the efficiency of irrigation. The high-yielding dwarf varieties are comparatively more exact in timely irrigation than the tall ones. At Ludhiana, it has been observed that depression in the vegetative growth of Kalyan sona wheat caused by water stress in the early stages could not be compensated by more liberal application of water in later stages.

Considerable work has been done to schedule irrigations on the basis of soil moisture depletion and the findings varied according to the soil and other conditions of the locality. The results of an experiment conducted on a black clay soil at Indore (Table-5) indicated that more frequent and light irrigations at 25% depletion of available soil moisture produced the highest yield of Kalyan sona wheat, though the total quantity of water applied was the lowest excepting the treatment of only one irrigation at crown root initiation in which the grain yield was reduced to half. The interaction between moisture regime and fertilizer application was found to be highly significant. The higher dose of fertilizer application was more beneficial at higher soil moisture regime, whereas at a given mositure regime the grain yield was greater at higher fertilizer level.

Lately, trials are being made to adopt climatological approach to schedule irrigations. At Ludhiana, Siruguppa and Chakuli centres, the results have shown that application of 60 mm irrigation water after cumulative U.S. pan-evaporation value of 60 mm or 80 mm (ratio of 1·0 or 0·75 resulted in higher grain yield of Kalyan sona wheat. The relevant data obtained at Ludhiana are given in Table 6.

Cotton. Maximum yield of Humpi cotton on black heavy soil at Siruguppa was obtained with 2 pre-flowering and 4 post-flowering irrigations, but further increase in the number of pre-flowering and post-flowering irrigations did not give any additional benefits. Flowering and boll formation have been found to be important growth stages for irrigation. In a clayey soil at Coimbatore, irrigation application at 0% availaable moisture produced as much yield of *Kapas* (seed cotton) as irrigation at 20% available moisture and resulted in saving of about two irrigations. The production of *Kapas* per cm of water came to 62·9 kg. in the former treatment as against 51·1 kg in the latter treatment.

Sorghum. In an experiment conducted with summer sorghum on a black clayey soil at Siruguppa it was observed that there was no significant difference in grain yield between different irrigation treatments. Since irrigation application at 75% depletion of available moisture resulted in higher moisture use efficiency

TABLE 7. SORGHUM (SUMMER) YIELD (q/ha) AT SIRUGUPPA AS INFLUENCED BY IRRIGATION AND NITROGEN

Nitrogen	*Irrigation at soil moisture depletion*			*Mean*	*C.D.5%*
	25%	50%	75%		
N_0	30	36	48	38	N–5
N_{60}	60	60	54	58	I–NS
N_{120}	67	62	60	63	NXI–10
N_{180}	71	77	77	75	
Mean	57	59	60		
Irrigation (cm)	43	41	37		
Yield (q/ha/cm)	1.3	1.5	1.6		

TABLE 8. EFFECT OF IRRIGATION ON YIELD OF SUMMER GROUNDNUT AT COIMBATORE

Moisture depletion	*Irrigation (cm)*	*Pod yield*	
		q/ha	*kg/ha/cm*
I_1—20%	90	12	13
I_2—40%	63	21	34
I_3—60%	50	16	31

TABLE 9. DISTANCE AT WHICH TO CUT BACK THE STREAM FOR VARIOUS DISCHARGE RATES AND SLOPES IN 140 m LONG BORDERS

Discharge rate in litre/sec/metre width of border strip	*Slope in per cent and opportunity time in minutes*							
	0.2		0.15		0.10		0.05	
	a	b	a	b	a	b	a	b
2.14	90	23	95	26	100	32	110	41
1.71	95	26	100	31	110	37	130	50
1.43	100	31	100	38	115	44	125	58

a = when to cut off the stream (m); b = opportunity time in min.

TABLE 10. EFFECT OF IRRIGATION METHOD AND QUALITY OF WATER ON RADISH YIELD AT HISSAR

Method	*Poor Water (EC 6500 micromhos/cm)*		*Good water*	
	Yield q/ha	*Yield q/ha/cm*	*Yield q/ha*	*Yield q/ha/cm*
Drip (50% of P.E. value)				
Surface	157	18	175	19
Sub-surface	236	26	268	30
Surface (75% of P.E. value)				
35 mm	99	9	163	14
65 mm	67	6	139	12
C.D. 5%	47		65	

and water economy as compared to the more frequent irrigations, irrigation scheduling at the former soil moisture depletion is considered economical. The water use efficiency increased with an increase in the level of nitrogen application. The relevant data are given in Table7.

Groundnut and Ragi. The work done on a clay loam soil at Coimbatore showed that irrigation application at 40% depletion of available moisture gave maximum pod yield of groundnut per hectare as well as per cm of water applied. More frequent irrigations at 20% depletion of available moisture required more water and also adversely affected both the yield and water use efficiency (Table 8). Almost similar observation was made with regard to ragi (CO-7) crop.

Irrigation Methods

Efficient use of irrigation water depends not only on the timely and adequate irrigation but also on the method of its application. The check basin method of irrigation is by far most popular among Indian cultivators. It has been observed that there was no significant difference in the yield of wheat in plot sizes varying from 10 × 10 m to 20 × 20 m and that the plot size greater than 20 × 20m or less than 10 × 10 m had a depressing effect on the yield in sandy loam soil at Hissar. On the other hand, the check basin size of 5 × 5m was found to give maximum water use efficiency in sandy soil at Jobner. The border strip method gives better results with provision of surface drainage. The distance at which the stream should be cut off in 140 m long borders for various discharge rates and slopes for obtaining more uniform water application, was worked out at Hissar and the results are given in Table 9.

The studies made on a black clay soil at Siruguppa (Mysore) on evaluation of furrow irrigation method have indicated that the stream size of 2·06 litres/sec could irrigate 159

TABLE 11. EFFECT OF SPRINKLER VERSUS SURFACE METHOD OF IRRIGATION AND NITROGEN ON POTATO YIELD (q/ha) AT HISSAR

Nitrogen	*Sprinkler*	*Surface*	*Mean*	*C.D.%*
N_0	98	81	89	N–19
N_{60}	161	101	131	M–22
N_{120}	166	103	134	
N_{180}	190	129	160	
Mean	154	103		
Irrigation (cm)	26	32		
Yield (q/ha/cm)	6	3		

TABLE 12. EFFECT OF LEACHING WITH POOR QUALITY WATER IN A SANDY SOIL AT JOBNER ON GRAIN YIELD OF WHEAT (g/drum of 55 cm diam).

Quality of irrigation water (ECX 103)				*SEM±*	*Leaching*			*SEM±*
2	4	8	12		10%	15%	30%	
31	35	23	26	8	23	38	26	7

TABLE 13. EFFECT OF DEPTH AND SALINITY OF GROUND WATER ON WHEAT YIELD AT LUDHIANA

Depth of water table (cm)	*Contribution of ground water (mm)*	*Grain yield (g/lysimeter)*			*Mean*
		Quality of ground water (EX X 106)			
		500	2900	5200	
60	380	147.5	74.8	48.0	90.1
90	329	179.8	92.2	64.2	112.1
120	165	158.2	124.5	98.0	126.9
150	120	122.2	108.2	94.2	108.3
Mean		151.9	99.9	76.1	
C.D. at 5% for water table depths		7.33			
„ for ground water salinity		6.35			
„ for depth X salinity		12.7			

TABLE 14. CONTRIBUTION OF GROUND WATER TO CONSUMPTIVE USE OF WHEAT (*RABI* 1969–70) AT I.A.R.I.

Water table	*Et (mm)*	*Contribution*		*Yield q/ha*
		(mm)	%	
Shallow (42–68 cm)	354	338	95	41
91 Deep (185–233 cm)	191	100	52	28

m length with uniform moisture distribution and higher irrigation efficiency was obtained in slopes lower than 0·53%.

The drip method of irrigation, which has an advantage of maintaining soil moisture at lower tension in the vicinity of the roots, was compared with the surface method on a sandy loam soil at Hissar. It resulted in higher yields of onion and sugarbeet with higher moisture use efficiency. In a similar study with radish crop, using good quality as well as poor quality irrigation water, the drip method proved much superior to the surface method in obtaining higher yields and greater water use efficiency in the case of both good and poor quality water. The subsurface drip was better than the surface drip (Table 10). In sandy soil at Jobner, 1·6 times more water was used in furrow method than in drip method to produce the same yield of potato. At Siruguppa, the growth and yield of sunflower crop under sub-surface irrigation was found to be superior to that under the surface method.

In a comparative study of sprinkler method versus surface method of irrigation with potato crop on a sandy loam soil at Hissar, the sprinkler method gave higher yield per unit area and per unit of water and resulted in 20% saving of water. The response to nitrogen application was also more in sprinkler method than in surface method of irrigation as shown in Table 11. In lateritic soil at Kharagpur, maximum uniformity co-efficient, in sprinkler irrigation was obtained at 12·2 m × 12.2 m spacing, 5·55 mm nozzle size, 2·5 kg/cm² operating pressure and 1 m height of the riser, whereas, in sandy soil at Jobner the same spacing with nozzle size of 6·25 mm operating at a pressure of 1·98 kg/cm² produced maximum uniformity co-efficient.

Use of Poor Quality Irrigation Water

The studies made on a black clay soil Siruguppa indicated that wheat yield was significantly reduced when irrigation waters with E.C. of 8 mmhos/cm or more were used, the yields with waters of EC 0·22, 2, 4, 8 and 16 mmhos/cm being 28·6 q/ha, 30·5 q/ha, 29·2 q/ha, 24·7 q/ha and 21·3 q/ha respectively. The depressing effect in sandy soil at Jobner was observed at E.C. of 12 mmhos/cm or above.

The results of the experiment conducted in a sandy soil at Jobner to evaluate the effect of leaching on the use of saline water are given in Table 12, which reveal that 15%

TABLE. 15. EFFECT OF DEPTH AND SPACING OF TILE DRAIN ON MAIZE YIELD (q/ha) AT INDORE

Depth	*Spacing* 6.5 *m*	19.5 *m*	39 *m*	*Mean*
60 cm	38.2	25.6	17.2	27.0
75 cm	24.9	19.7	24.1	22.9
90 cm	24.1	23.9	14.6	20.8
Mean	29	23.1	18.6	

TABLE 16. EFFECT OF SHALLOW OPEN DRAINAGE IN A HIGH WATER TABLE SALINE AREA AT I.A.R.I.

	Sorghum (Kharif 70)		*Wheat (Rabi 71)*	
	Undrained	*Drained*	*Undrained*	*Drained*
Grain yield (q/ha)	Failed	47.6	6.8	42.8
ECe X 10^3 of soil				
Surface	8.6	4.6	27.4	1.3
0–20 cm	3.2	0.9	9.6	1.1

leaching was sufficient to keep down the salts and a further increase in leaching from 15 to 30% did not give any additional advantage for the local soil. Almost similar trend was observed at Hissar.

Critical Depths of Water Table for Crop Growth

In a lysimetric study with constant depths of water table and varying qualities of water carried out at Ludhiana, maximum yield of wheat (Kalyan Sona) was obtained at 90 cm water table depth with good quality water and there was reduction in yield below and above this water table. In case of saline water maximum yield was obtained with 120 cm depth of water table. The capillary contribution from 60 and 90 cm depths of water table amounted to almost more than 2 times that in case of deeper water table (Table 13).

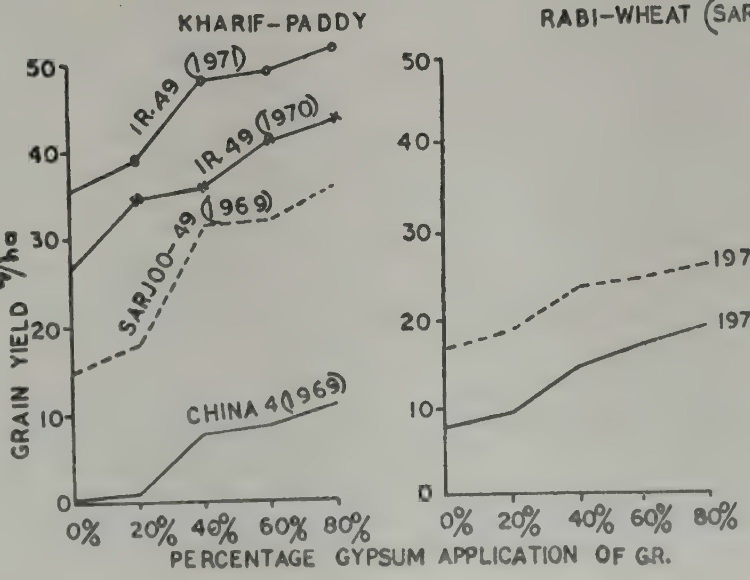
In a lysimetric study conducted at I.A.R.I., the depth of water table in the range of 50-100 cm was found to be more favourable for wheat, peas and *toria*, particularly in the case of first two crops. This points out the necessity of drainage in areas having water table less than 50 cm and of adequate supplemental irrigations in areas with water table below 1 m. The capillary contribution from 25 and 50 cm depths of water tables came to about 544 mm and 443 mm respectively during a period of 136 to 141 days, and it declined sharply with increase in the depth of water table. In another experiment at I.A.R.I. it was possible to grow successful crop of wheat without any supplemental irrigation due to substantial capillary contribution from the high ground water table, as shown in Table 14.

Drainage of Lands Having High Water Table or Salt Infestation

In an experiment conducted on a clayey soil having high water table during the rains at Indore, the tile line laid at 60 cm depth and at 6·5 m spacing resulted in higher yield (49 to 122% more) of maize as compared to the other greater depths and spacings of the tile drainage (Table 15). In heavy black soil with somewhat better structure at Siruguppa, on the other hand, 1·2 m depth and 12 m spacing have been found to be optimum for subsoil tile drainage to push the water table below the root zone and also to leach down the salts.

In a high water table saline area of sandy loam soil at I.A.R.I., introduction of 1 m deep open ditches 32 m apart lowered the water table and salt content and also resulted in obtaining good yields of sorghum and wheat crops as against almost complete failure in the undrained plot (Table 16). Water table varied from 3 to 59 cm in the undrained area and 49 to 93 cm in the drained area.

FIG.1- EFFECT OF GRADED GYPSUM APPLICATION ON YIELD OF PADDY AND WHEAT ON SALINE SODIC SOIL



Amelioration of Saine Sodic Soils

An appreciable portion of about 7 million hectares of land estimated to be affected by soil salinity in India is due largely to faulty use of irrigation. Although some isolated efforts were made in the past to find out techniques for the reclamation of such soils, the results were of sporadic nature and were not translated into actual practice in the field. The recent studies carried out at Indore (black soil) and Kanpur (alluvial soil) have shown that gypsum is a very useful amendment and its addition at 40% to 60% or above results in considerable improvement of soil conditions and in increased yields of paddy and wheat crops. The data obtained at Kanpur are illustrated in Fig. 1.

The results achieved so far under the All-India Coordinated Project for Research on Water Management and Salinity indicate that with the use of proper water management practices and irrigation methods depending upon the crop and the local soil and climatic conditions, the efficiency per unit of water can be increased considerably and maximum crop productions can be achieved with less water. The large quantities of water, thus saved, can be utilised for irrigating other areas where cultivation is done hitherto under rainfed conditions. The delivery system of irrigation water by the Irrigation Department needs to be re-oriented accordingly for most efficient and economic use of water. These results also provide scope for utilizing poor quality water for irrigation in agriculture without much harmful effects. Besides, an appreciable portion of the salt affected and high water table areas can be reclaimed successfully for economic crop production with adoption of suitable technology. The desirability and importance of further intensified research on various aspects of water management covering other crops which are of economic value but on which very little information is available in this regard, is also indicated.

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ADVANCES IN AGRICULTURAL EXTENSION EDUCATION

S. K. SHARMA
Asstt. Director General, I.C.A.R, New Delhi

During the last few years Indian Agriculture has started to move from static to scientific agriculture. Agricultural technology is changing at an increasingly rapid rate. In fact, the expansion is taking place in the area of agricultural research. But our tools and techniques of disseminating these technological innovations and helping farmers equally have contributed considerably towards agricultural production. Today, agricultural extension education in India has a network of large professional extension workers on national, states, district, block and village levels. Efforts are being made to bridge the gap between the available agricultural technology and its adoption by the farmers through agricultural extension education. Nevertheless, agricultural extension education is one of the youngest sciences. Further, it is an applied science the knowledge of which has to be employed in its growth as a profession and science.

The major areas of research in agricultural extension education could be confined to:—

(i) adoption and diffusion;
(ii) extension teaching methods;
(iii) extension programme plannings;
(iv) Misc. (communication, training, administration, etc.)

A close perusal of the research conducted in the above mentioned areas so far indicate that the majority of them constitute applied research.

Adoption and Diffusion

Studies conducted on adoption and diffusion of agricultural innovations primarily focus on knowing farm practices associated with adoption and to find out the influence of change, contacts and the various sources of information on the adoption level. The extent of adoption of improved farm practices by the farmers have been studied with special reference to major crops of the area such as rice, jowar, sugarcane, groundnut, maize crops and so on. Most of the researches indicate that the practices which were adopted to a high degree, were the use of improved seeds, application of nitrogenous fertilizers and plant protection measures. Those which were adopted to a less extent included the application of phosphatic and pottasic fertilizers, pre-treatment of seeds against insects, pests and diseases and use of improved agricultural implements.

In majority of the cases it was found that farm size, education and social position of farmers were positively associated with the extent of adoption.

It did not consistently indicate a positive or negative association with adoption. The implications of these findings to the extension workers seem to be that while it may be desirable to approach the more progressive, well-to-do and educated farmers to get early acceptance among the community of recommended practices, the extension worker cannot afford to neglect the farmers who are less educated, with small farms and belong to older age groups, since factors other than those mentioned above also influence adoption. The researches carried out in the field of extension and adoption have also shown the positive influence of change agent on the extent of adoption. Farmers who have frequent contacts with change agents were found to be better adopters than those who had less contacts.

Similar studies have also been conducted in the areas of animal husbandry and poultry keeping.

The sources of information in the diffusion and adoption process have also been studied with reference to improved agricultural and animal husbandry practices. The studies in general revealed that the Government agencies especially Village Level Workers and extension workers followed by friends and neighbours were the main sources of information for all types of improved practices. These studies also showed that in the process of adoption (in stages of awareness, interest and trial) Government agencies played a very dominant role. In the trial stage the informal sources such as friends and neighbours had influenced to some extent the adoption of innovations, thus pointing out the need for developing local leadership to strengthen the formal extension services.

Extension Teaching Methods

Efficient use of extension methods is most essential for dissemination of agricultural information among the farmers. A large number of researches have been conducted in this area indicating the relative effectiveness of various extension methods and the factors influencing their effectiveness.

Individual contact method has been found as the best approach method, while contacting an individual and his family, farm and home visits have been termed significantly superior among individual contact methods in the first information stage of adoption process.

Nevertheless, method and result demonstrations have been found to be most effective of all the methods for motivating farmers to adopt agricultural innovations. Demonstrations primarily have been found most effective on awareness and interest stage of adoption process. Similarly, group discussion was found superior to other methods specially for farmers of age below 35.

As regards mass contact, news stories, bulletins and circular letters were less effective than exhibition and radio at awareness and interest stages of adoption. Radio was the first among mass-media methods in adoption of seeds and fertilizers. As regards some audio-visual aids their relative effectiveness is found in the following ascending order, i.e. motion picture, leaflet, charts, wall-newspapers—whereas the percentage of farmers who were found stimulated to further action by different audio-visual material is in the following descending order, leaflets, wall-newspapers, motion pictures and charts.

A combined use of several different methods of approach is found to be of utmost importance in extension teaching. The adoption practice has been high where more than five methods were used as compared to single and 2 to 5 methods. The research work done in the field of extension methods in audio-visual aids has been carried out primarily by the post-graduate students of Agricultural Extension Education or primary cross-sectional service based on limited sample size.

Demonstrations

Based on effectiveness of demonstrations in terms of educating farmers a nation-wide demonstration programme of national demonstrations was initiated in 1965 for properly demonstrating the potentialities of high-yielding varieties to the farmers. Since then the programme has grown in its dimensions and its approach. The keynote of the demonstrations at present is multiple cropping and the main emphasis of the programme is on transfer of technology for maximising production per unit area and in per unit time. At present the programme is in operation in 100 intensive districts. Its achievements since 1965 in terms of demonstrations attaining targetted yield of 9 and 11 tonnes per hectare in 2 or 3 crops respectively as well as the performance of individual crops are given in Table 2.

The yields obtained in important crop rotations having food crops during the last 4 years are given in Table 1.

Communication

Recently the agricultural strategy in India called for speedy dissemination of agricultural information to the farming community. Radio and television have proved to be most important media which promise to satisfy the need of the day. Radio has been an established medium of mass education in farming whereas television has recently been introduced on experimental basis in Delhi to diffuse technological know-how to farmers.

Radio has proved an effective mass-communication media in proving significant change in knowledge and attitude of farmers of various social and economic strata. Nevertheless, the farmers listening to community radio sets register higher degree of change in the attitude and knowledge. The mode of delivery of information through the radio also seem to vary in the effectiveness. Conversational mode of delivery is superior than the straight talk in terms of change in attitude and knowledge of the farmers. In India television is a newly introduced medium of communication and it was in 1959 when for the first time television transmitter and studio were installed with the primary purpose of imparting adult education. On January 26, 1967, the Prime Minister of India, Smt. Indira Gandhi, formally inaugurated special T.V. programme known as 'Krishi Darshan' for dissemination of improved agricultural management practices in villages of Delhi territory.

The studies conducted by Sharma and Mishra (1968), Sharma and Dey (1969), Sharma and Sinha (1970) and Sharma and Singh (1972) have clearly indicated the effectiveness of television in terms of disseminating the knowledge of improved agricultural practices to the farmers. It showed that the farmers gain knowledge significantly through television and even its retention after 15 and 30 days telecast was equally significant. The effect of age, caste and economic status to the effectiveness of television was insignificant indicating that television is the best medium to approach the farming community. The above mentioned studies quite naturally support the introduction of T.V. for informal agricultural education. It would serve the need of a very efficient information transfer system. They further recommended that the use of television be pressed into agricultural services at the earliest.

In the light of above researches it can be clearly stated that a satellite television system together with ground stations capable of covering all villages should be installed in the country as early as possible. The investment will certainly be heavy but the return in the form of increased production and raising of sights of the rural community may be much more than the total investment on the television system.

Training

The researches carried out in the field of training under agricultural extension education primarily focus on training of extension personnel such as Villege Level Workers, Extension Officers, Block Development Officers, etc. The main objective of these researches has been

TABLE 1.

Rotation	1967-68		1968-69		1969-70		1970-71	
	Average yield in quintals per hect.	*Percentage exceeding target*	*As per Col. 2*	*As per Col. 3*	*As per Col. 2*	*As per Col. 3*	*As per Col. 2*	*As per Col. 3*
1	2	3	4	5	6	7	8	9
Jute Grain Paddy Paddy	9.97) 2.13)	90	10.34) 2.14)	64	8.60) 2.00)	83	13.49) 1.91)	100
Paddy Paddy Paddy	13.31	94	15.49	100	16.60	100	16.43	100
Maize Wheat Maize	10.67	31	12.59	91	12.60	100	9.31	25
Paddy Wheat	9.03	65	9.67	69	9.80	67	9.70	77
Paddy Paddy	10.49	73	9.45	77	10.42	84	11.27	84
Bajra Wheat	7.98	50	7.70	30	7.10	40	7.71	35
Jowar Wheat	6.48	13	8.19	44	8.20	29	8.44	50
Maize Wheat	8.07	51	8.78	50	8.04	42	8.20	45

to ascertain job perception, job performance, adequacy of pre-service training, in-service training and effectiveness to teaching aids and methods that are used to impart this training to the above mentioned personnel. Few studies have also focussed on the ways and means of improving field programme of these personnel. By and large, studies have clearly delineated the areas requiring additional practical training for developmental staff.

From the researches carried out so far in this field it transpires that the developmental staff, Villages Level Workers in particular, are not conversant with their educational role as communicators and catlaysers in the agricultural development programme.

In addition, it has also been indicated that the training imparted to the farmers and farmers' sons is really meaningful for imparting technical know-how in agriculture. Quite a few studies have shown that the absence of monetary incentives, unfavourable family circumstances, old age, etc., were made training avoidance motives. A few studies have suggested that the time for training be increased especially for practical classes. For effective training the farmers should be of the age of 20 to 40 years and only interested and tillers of soil should be called for such training courses.

The Way Out

Nearly 500 and odd researches have been conducted so far in India in the field of Agricultural Extension Education but there is hardly any evidence to substantiate the basis of extension research in this field. Again, scientific approaches have hardly been employed in this regard, i.e. in the selection of research problems. Moreover, the bulk of research in agricultural extension education have been conducted with a view to obtaining M.Sc./Ph.D. degree in the subject of Agricultural Extension Education.

There is however nothing wrong in conducting research through the students as most of the researches in other subjects too are due to the sincere efforts of the post-graduate students. Still in Agricultural Extension Education the research has been so planned and executed as to obtain degrees.

If the agricultural education has to stay as an educational subject, the persons engaged in it can no longer afford the luxury of conducting researches for the sake of research. In fact, they have to start planning and conducting research programme in such a way that in few years time adequate systematic knowledge is obtained and its findings could be amply utilized in Agricultural Programmes of the country. Thus the scope of research in agricultural extension education is tremendous.

A few suggestions are given below for the future line of action for researches in agricultural extension education.

(i) there is need to consolidate all the researches carried out in the field of agricultural extension education so far including the methodologies employed to conduct. The extent to which these functions have been or are being utilized by all these engaged in agricultural extension education also need to be determined;

Years	*No. of demonstrations reported*			*Percentage exceeding targetted yields*
	Multiple crop	*Single crop*	*Total*	
1965–66	—	416	416	—
1966–67	—	999	999	—
1967–68	920	547	1467	55%
1968–69	915	171	1086	58%
1969–70	858	457	1315	58%
1970–71	1108	342	1450	60%
1971–72 (Kharif only)	results awaited	1500		

(ii) areas of researches should be selected on priority basis from the points of view of (a) growth and development of agricultural extension education and science and (b) increasing efficiency of the profession of agricultural extension education;

(iii) available resources be kept in mind so that the agricultural extension research programme could be carried out successfully;

(iv) the research programme primarily should have on the problem oriented approach so as to provide immediate guidance and impetus to the agricultural extension programme in the country.

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Pioneering Work in
Fibre Quality Assessment

JUTE TECHNOLOGICAL RESEARCH LABORATORIES

S. B. BANDYOPADHYAY
Director, Jute Technological Research Laboratories
Indian Council of Agricultural Research, Calcutta

MORE than a century old though the jute industry is, regular research on jute was taken up only in 1936 when Indian Central Jute Committee was constituted to carry on research for the improvement of quality and outturn, as well as to find new uses of jute.

The Jute Technological Research Laboratories, Calcutta, began functioning in 1938; its agricultural counterpart, the Jute Agricultural Research Institute was started in 1939. The laboratory buildings were extended in 1959, and after the Indian Council of Agricultural Research took over in 1966 further strengthening took place during the Fourth Plan period. It now constitutes four divisions—Textile Technology, Physics, Chemistry and Chemical Technology, and Testing Section, Library and Museum.

Fibre Quality and Agricultural Practices

On quality aspect of fibre, Technological Research Laboratories did pioneering work in the field of fibre quality assessment. Of these, mention may be made of the technique of measuring the spinning quality of fibre from small-scale trial on standard jute processing machinery, and designing instruments for the measurement of fibre strength and fibre fineness, the two important characters determining the quality of fibre. Dozens of fibre bundle strength testers made in the laboratory are now in use in jute mills and research and development centres. These quality evaluation techniques had been of much help in evolving the jute strains like JRO-632, JRC-212 and JRC-7447, as well as the norms of agronomical practices, such as—

(a) Not to increase the dose of nitrogenous fertilizer beyond the recommended limits, since high dose of nitrogenous fertilizer was found to lower the quality of jute fibre.
(b) To sow jute seeds in narrow spacings, since this practice produced thin plants which give good quality fibre, along with increased plant population.
(c) To harvest jute plant early and leave the plots for other crops, since the short-duration crop was found to be in no way inferior in quality to the mature crop.

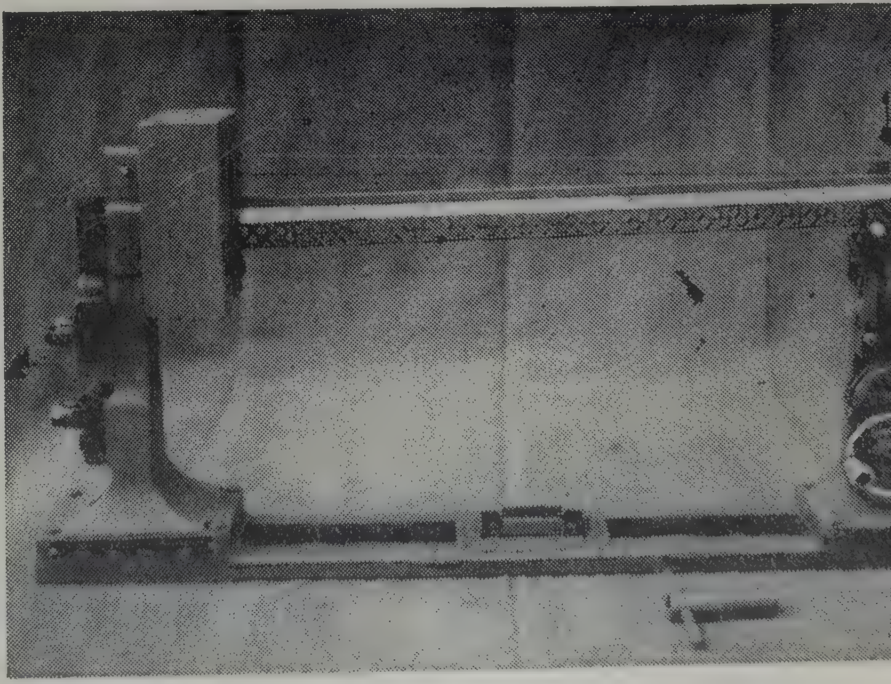
With the micro-testing methods developed in the laboratory it is now possible to determine the quality of fibre obtained from 4 to 5 plants, and thus to help the plant breeders in breeding for fibre quality.

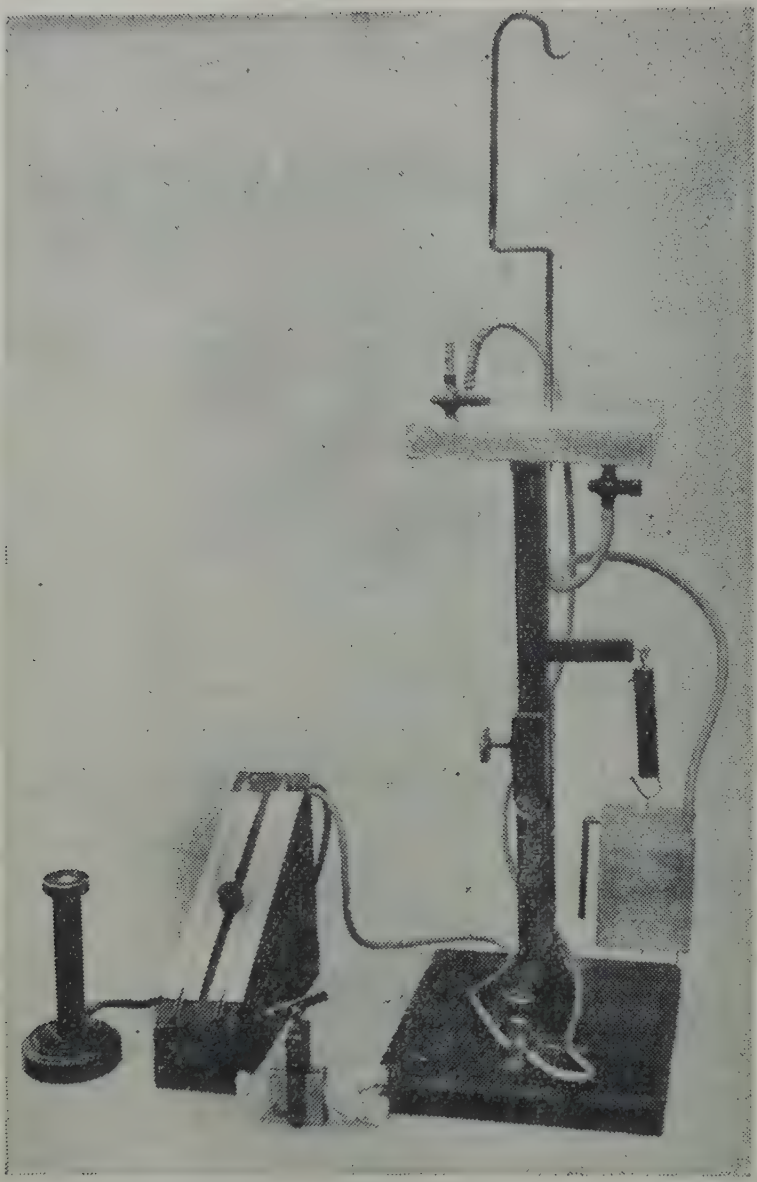
Fibre Quality Survey. The laboratory carried out surveys of the quality of commercial fibres from different jute growing States which brought out the areas producing good or bad quality jute. This would enable the states to take steps for improving the quality of fibre or reducing the acreage of the low quality areas giving preference to high quality areas.

Jute Grading. Extensive work carried out in the laboratory on various physical properties of fibre and yarn of different varieties provided suitable methods for testing and grading of fibre as well as of estimating the spinning value from fibre characters. This has made it possible for the Indian Standards Institution to bring out standard specifications for different grades of jute in a more scientific way.

Physical Nature of Fibre. The Institute's programme on basic research on rheological and frictional properties,

JTR Jute fibre bundle strength tester





JTRL Air flow fibre fineness tester

and on fine structure on fibre revealed different aspects of the physical nature of jute fibre, which contribute towards high strength and dimensional stability of jute cloth, and the function of oil and water in softening the fibre. Some physical contents are given in Table I.

New ideas in jute processing. Studies on jute processing system carried out in this laboratory have clarified some of the old ideas and introduced new ones, as regards the effects of various machine factors, stapling of jute fibre, etc.

Jute Substitutes and Blends with Jute. Just after independence when India faced jute scarcity, mesta and roselle were for the first time satisfactorily processed in the laboratory on jute machinery, as a result these fibres are now accepted as raw materials for the jute industry and their cultivation is continuing with greater impetus. As measures for facing jute scarcity periods procedures of blending jute with, low grade sunnhemp, abutilon fibre, linseed flax were also established.

Rayon staple blending with jute was successfully tried on jute machinery, the fabric produced from the resultant yarn raised the value of jute and could be used in decoratives.

Chemical nature of fibres. Systematic studies were carried out on the chemical constitution of bast and leaf fibres as well as other agricultural raw materials; chemical structure was also studied in some cases; this knowledge has been the basis for the determination of the scope of modification of these fibres by chemical treatments, to make them suitable for diversified uses. The proportion of some of the major constituents are given in Table II.

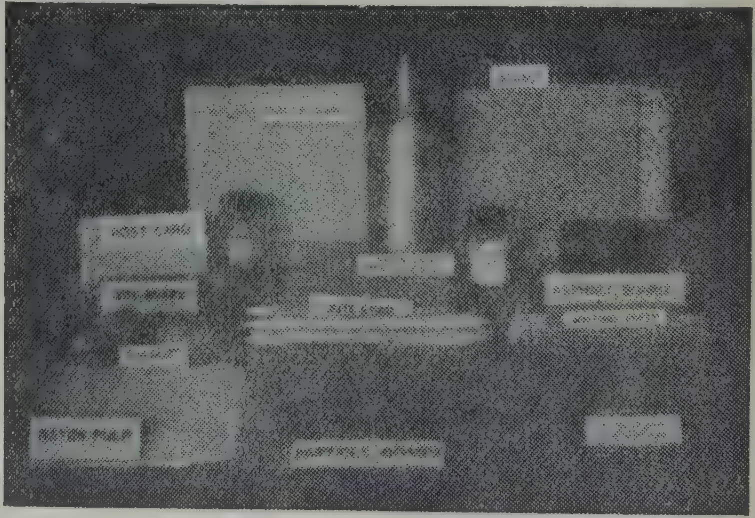
Bleaching and Dyeing. The laboratory developed a technique of bleaching jute, a brownish lignified fibre, with sodium chlorite and also with hydrogen peroxide; the latter process which involved much less loss in weight and fabric strength was released for the industry after detailed studies. This opened up a new vista for the use of jute in making fabrics of more aesthetic nature which have a much higher export value. Suitable dyeing process was also recommended for jute fabrics to be used for wall-covering and drapery and furnishing materials. This has given impetus to the jute industry to go further ahead for exploiting the export trade in this field.

After-yellowing is a problem of bleached jute. A cheap process developed in the laboratory would partially solve the problem. The process produces a stable pinkish colour instead of continuously deepening brownish shade which changes the hue of dyed materials from the bleached fabric.

Introduction of new properties. Work in this laboratory showed that water repellency as well as microbial resistivity could be developed in jute or jute products by treatment with chemicals made indigenously. High polymer grafting on jute reduced its moisture absorption capacity.

Bleached jute fabric was effectively treated by u-f resin under suitable conditions for improving its wet strength and dimensional stability. This would impart new quality to the decorative fabrics with nominal extra cost.

Jute stick products



Quality Improvement by Treatment

Barky root-cuttings which constitute about 20 per cent of the total quantity of jute processed in a mill form a substantial loss to the industry. The Jute Technological Research Laboratories introduced the ammonium phosphate process which stimulated bacterial action for softening these hard roots; this enabled the industry to spin fibre mixtures containing up to 40% of softened root cuttings. A new 'fungal' process has been evolved in the laboratory by which root cuttings were spun alone in laboratory spinning trials; large-scale trials in mills are being awaited.

Chemical treatments were evolved for removing the dark shade of grey jute; method of brightening dark hessian was developed. The brightened hessian had a good foreign market. These researches thus helped in raising the value of jute.

To keep up the foreign market of jute, the laboratory developed improved woolpacks which removed the complaints regarding contamination of wool with jute fibres coming out of jute yarns, with the full satisfaction of the wool traders in Australia. Seepage of cement and moisture absorption in cement bags were reduced by suitable treatments at a small extra cost.

New uses of jute. The laboratory showed that on woollenisation treatment jute can be well-mixed with wool for making cheap blankets, wrappers and knitting yarns; their qualities were also satisfactory. With 50:50 mixture woollenised jute-wool knitting yarns appeared practically similar to all wool yarns. These products will not only provide warmth to the poor at a cheap rate but also help new industry to grow.

Jute-stick utilisation. About 2.3 tons of jute-stick are produced for each ton of the fibre. The total production of jute and mesta stick may go up to 3 to 4 million tons. Most of it goes waste. Its economic utilisation would fetch money to the growers and thus help cost reduction in raw jute. The laboratory has made various products from jute-stick for its utilisation, either after pulping or directly in the form of particle boards—

(a) Since 40% of jute-stick is alpha-cellulose, different pulping processes were tried.

TABLE I. PHYSICAL CHARACTERS OF SOME PLANT FIBRES

	Jute	*Mesta*	*Roselle*	*Sunn*	*Ramie*	*Sisal*
1. Cell-Length (L) mm	0.8–6.0	2.0–11.0	1.5–3.5	5.0–20.0	20–250	5–6
2. Cell-Width (B) μ (10^{-3} mm.)	5–25	13–34	10–32	12–35	15–80	5–40
3. L/B Ratio (Av.)	110	140	100	450	3500	150
4. Filament Grav. Fineness (Tex)	1.25–4.00	3.5–5.5	2.8–5.5	5.5–17.0	0.45–0.85	16–35
5. Extn. at break (%)	1.5	1.5	1.5	3.2	3.8	3.0
6. Tenacity of fibre bundle (g/tex)	13–30	16–30	12–30	15–35	28–40	22–36
7. Density (g/cc)	1.445	1.448	1.468	1.450	1.528	1.450
8. Porosity (%)	14.0	17.5	—	12.5	7.5	30
9. Moisture regain (%) at 65% R.H.	12.0	13.0	12.5	10.5	6.5	11.0

TABLE II. MAJOR CONSTITUENTS OF DIFFERENT FIBRES AND PLANT BY-PRODUCTS

Material	*Holocellulose* (%)	*Alpha-cellulose* (%)	*Lignin* (%)	*Pentosan* (%)
Jute fibre	83.0	60.5	13.3	12.4
Mesta fibre	87.4	60.0	10.1	14.8
Roselle fibre	88.2	59.7	9.9	15.0
Sisal fibre	89.2	63.9	8.6	17.9
Sunnhemp fibre	93.8	78.3	4.0	3.6
Jute stick (Cap.)	72.7	40.8	23.5	22.1
Jute stick (Oli)	71.2	39.3	25.2	22.0
Mesta stick	77.2	39.0	25.1	24.5

- (i) Conventional sulphate processes yielded about 45% pulp, which could be used alone or in mixture with long-fibred pulp, for making paper of various grades; a few paper mills are using jute-stick.
- (ii) Box-board suitable for cartons were made from pulps obtained by high-yielding (75-80%) lime digestion process. Some entrepreneurs are trying to use the process.
- (iii) Possibility of producing newsprint type of paper was shown by the use of mechanical pulp of 95% yield.
- (iv) Rayon grade pulp with 25% yield was also made from jute; stick, and with the help of a German firm high tenacity tyre cord rayon was made out of it.
- (v) Nitrocellulose prepared from jute-stick pulp was made into celluloid and lacquer varnish, which were comparable to standard varieties.
- (vi) A flexible roofing material was also made from an asphalt—jute stick pulp composition.

(b) Masonite type hard particle boards of different thermal and electrical properties made in the laboratory indicated the possibility of their being used for various building materials.

(c) Whole jute seed plant was also shown to be capable of being made into kraft paper.

Utilisation of jute mill waste. It has been shown in the laboratory that short-fibred industrial waste like jute caddies from broad looms can be used for making non-woven fabrics suitable for wall-covering buckram, etc. A few industrialists have also shown their interest in these materials.

Ramie Processing. Ramie is a fibre of very high quality. Its cultivation is yet to be taken up on a large-scale in this country. So for immediate utilisation of raw ramie a technique of processing the fibre on jute machinery was developed. The yarn thus produced was suitable for sewing twines.

Processes for chemical degumming of the fibre and spinning the same on jute machinery have also been developed. On staple fibre machinery blends of terene and ramie (67 :33) were spun; the yarn thus produced was woven and found to be quite suitable for suitings.

Banana plant fibre. Banana plant fibre, which practically goes waste, have been successfully processed by the laboratory on jute machinery by a special technique developed for the purpose. The cloth produced satisfied the I.S.I. Specification for jute cloth.

In the coming years the Institute proposes to make further headway in research on selection criteria for fibre quality, modes of fibres extraction and mechanical processing, chemical modification of fibres and waste utilisation.

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Rauvolfia vomitoria—a young growing plant

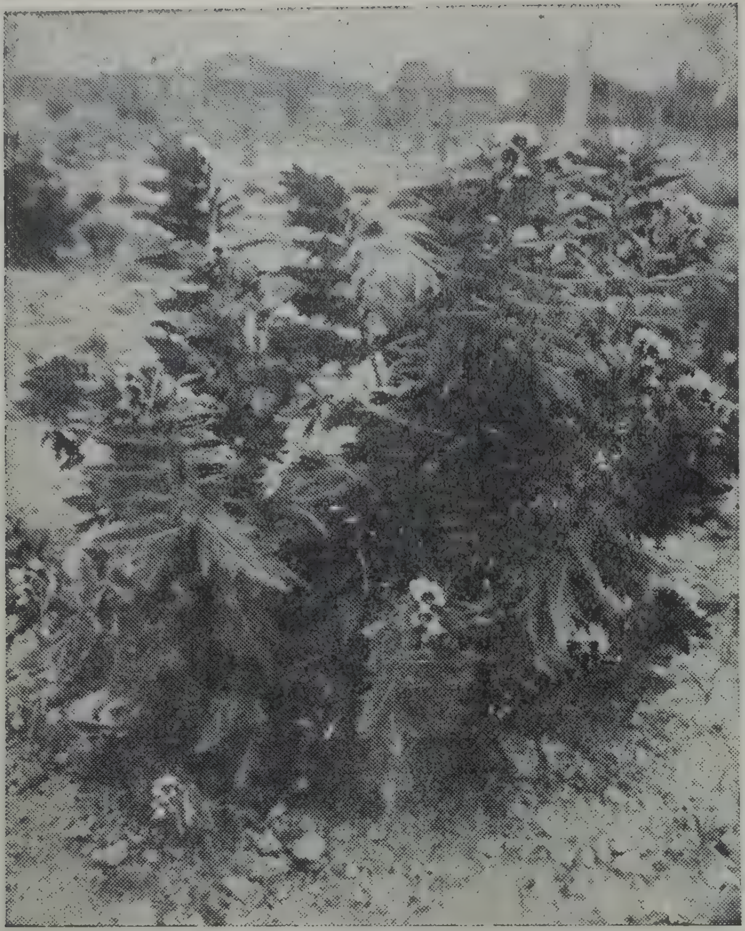
VITAL DRUGS AND ESSENTIAL OIL BEARING PLANTS AS FUTURE CASH CROPS IN INDIA

RAJENDRA GUPTA
Project Co-ordinator (Medicinal and Aromatic Plants), Indian Council of Agricultural Research, I.A.R.I., New Delhi

A FAMOUS nineteenth century botanist, Hooker (1904), described the flora of India as "more varied than that of any country in the Eastern Hemisphere, if not the whole globe." About 18,000 species of flowering plants have been reported to occur within the geographical boundaries of this country. A total number of 6,700 species are recorded to be endemic to this region, of which the Himalayas alone account for 3,169 dicotyledon and about 1,000 monocotyledon endemic plant species. Some 2,500 species have been known to possess medicinal virtues that the Aryans made use of against all forms of ailments. In addition, 1,300 species are reported to contain odoriferous principles, which made this land famous for its scented roots, woods, leaves, flowers and essential oils, attracting large number of travellers and traders from all over the wide world.

Our vegetable resources indeed, are magnificently varied and distinctly valuable. However, we have done little to harness this rich wealth of plants for industrial development. The Pharmacopoeia of India, sadly recognises only 70 plant species—a number too meagre to compare with 38 per cent drugs of vegetable origin listed in National Pharmacopoeia of the USSR. Similarly, hardly two dozen essential-oil-bearing plants are made use of by Indian perfumery industry; the indigenous food flavour industry is an infant at present to merit consideration. Ninety per cent of our export trade in essential oils is made up of oils of Sandalwood, Lemon grass and Palmarosa grass. Obviously, this betrays nature's vast treasure of plant resources of India.

The wild plant population is the natural source of germplasm for all plant industries. Large phytochemical establishments, however, require a regular supply of enormous quantities of raw material which commercial cultivation alone could support. In 1961 the Government of India decided to set up a phytochemical project for manufacture of nine basic pharmaceuticals at a total capital cost of 6.67 crores at Narimangalam in Kerala State. This project did not materialise largely because regular supply of raw material could not be assured. The cold fact of our dependence for vegetable drugs on collection from wild growth became too clear to miss its real significance. Still more painful was the revelation that scientific technology for commercial cultivation of these plants was largely unknown. Experimental cultivations have been attempted in the past at a number of state and central research institutes but package of practices were neither worked out nor were tested on any project scale trials to base industrial production for several years to come. There has been fresh



Hyocyamus muticus

thinking on this subject and many new developments have since then taken place. We shall now consider these measures to organise cultivation of this group of industrial plants as future cash crops in the country.

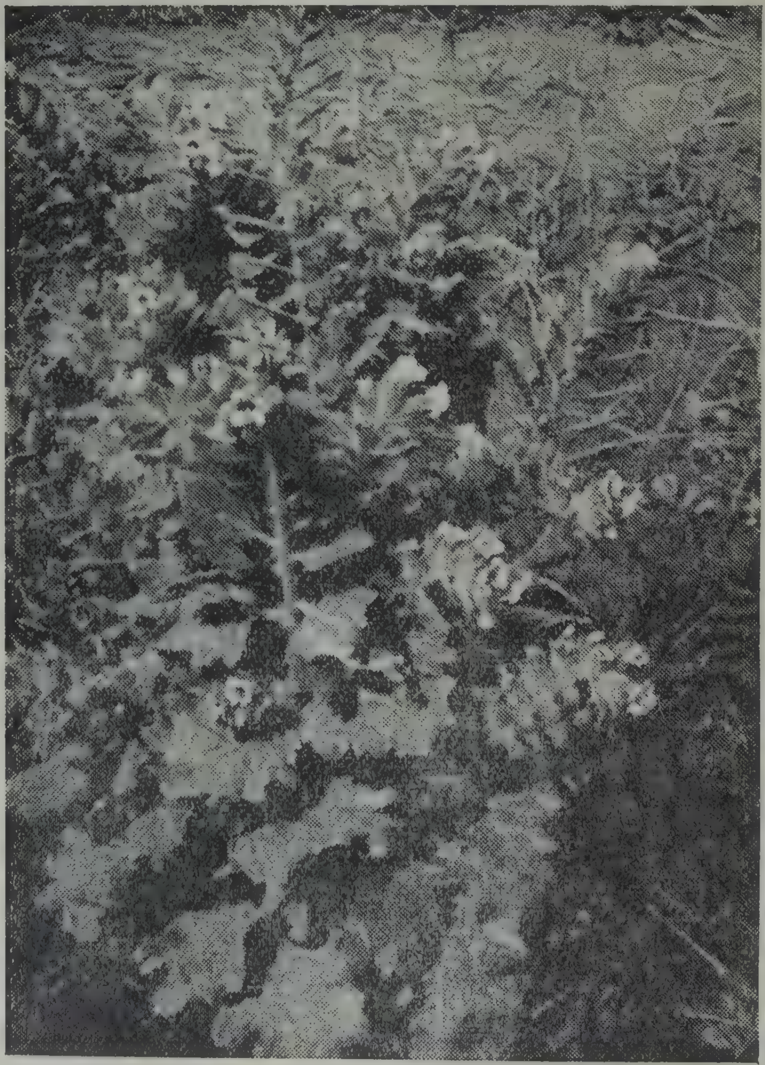
Drugs, Perfumery Material and Common man

There are few fields of human activity which involve us more deeply than drugs. The pharmaceutical discoveries of the last three decades have thrown up some new vegetable drugs to give relief to man from many dreadful diseases. In India itself, there has been spectacular expansion and improvement in health services for better medical care, reducing infant mortality and increasing life span of its people. However, prices of the drugs produced in organized sector of the industry is a tale of continuous rise. Kefauver report has made some unsavoury comments on the pricing of drugs in India. It says, "As a matter of fact, in drugs generally, India ranks amongst the highest priced nations of the world—a case of inverse relationship between per capita income and the level of drug prices." A recent survey on per capita expenditure on drugs and pharmaceuticals in India is estimated at Rs 3.62 in 1967; corresponding figures for Portugal, Belgium, Italy, Netherland, Japan and U.S.A. are Rs 32.57, Rs 58.72, Rs 97.42, Rs 96.43, Rs 117.47 and Rs 193.43 respectively. Thus the vegetable drugs, which cater to the needs of the vast majority of rural India has a special role to play in maintaining the cost of health services within reach of the common man. The state and the industry has therefore to accord priority to this sector and plan significant investment in research to develop and perfect technology from cultivation to manufacture of finished products within the country.

Perfumery material and essential oils cover a wide range of human activity. It enters into the manufacture of soaps, cosmetics, detergents and pharmaceuticals. Edward Sagarin has summed up its place in our life lucidly. He says, "From dawn until twilight and long into night and from the cradle of the infant to the silence of the grave, we are surrounded by the odorous materials. We take our odours for granted and little realise how much we would be affected, if our lives are deprived of perfumes."

Present Position

The collection, processing and sale of vegetable drugs in India is in the hands of small herb collectors and traders and except a few items, which we shall discuss, little fall in purview of organised sector of the industry. Estimates on annual production of vegetable drugs and essential oils and their consumption within the country are simply not available. We have therefore to resort to examination of import and export statistics published in trade

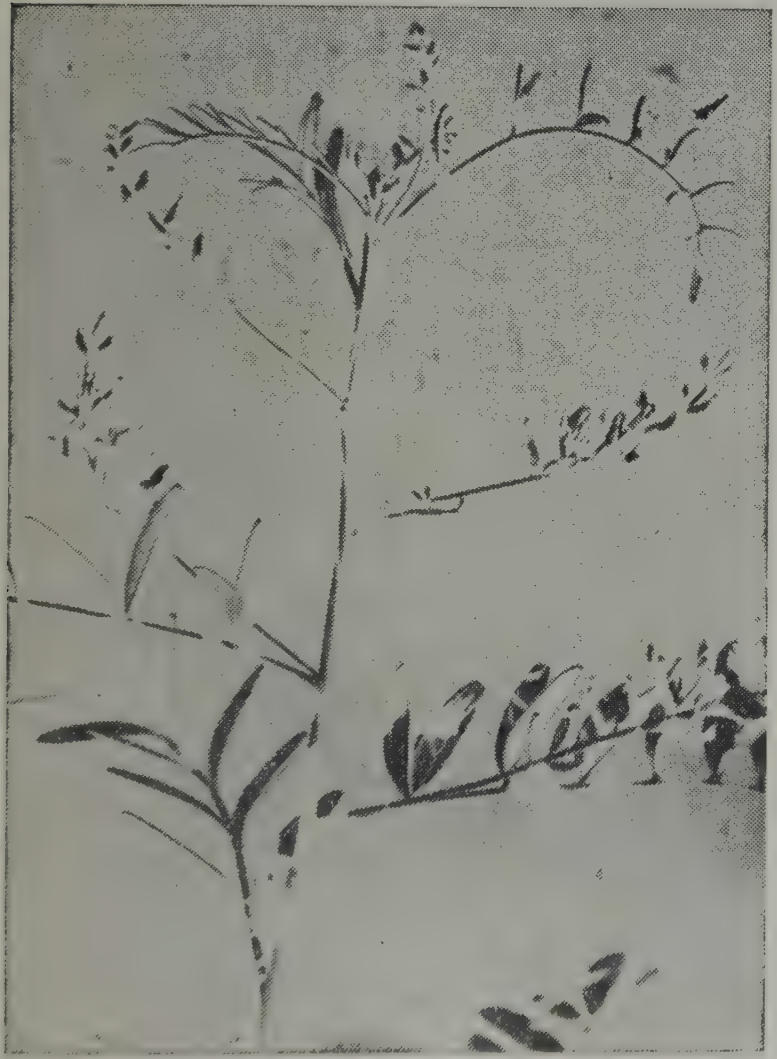


Hyocyamus niger

journals. The import of alkaloids, glycosides, essential oils and aromatic isolates come to Rs 3.22 crores annually (Table 1); the export trade in these items exceeds Rs 10.85 crores (Table 2). We also exported pharmaceutical preparations for a total value of Rs 3.60 crores (1970-71) to the countries of West Asia, South-East Asia and Africa.

The planting of *Cinchona* is an age old introduction and about 4,000 ha are under this crop in the states of West Bengal and Tamil Nadu. In addition to meeting our own requirements, these plantations bring between Rs 75 and Rs 90 lakhs in foreign exchange annually. The steep rise in demand since last about eight years should induce us to plan improvement in planting and extraction methods including renovation of the old, inefficient processing factories. *Caffeine* is another basic pharmaceutical whose production could immediately be raised for export. It is estimated that over 8,000 tons of tea waste, enough to manufacture 200 tons of *caffeine* are available with tea plantations in India. The current annual production is estimated as 80 tons against installed plant capacity of 118 tons. It would surprise many to learn that a huge quantity of the tea waste is stated to be burnt at site annually under provisions of Tea Waste (control) order of 1959, which should be suitably ammended.

Glycyrrhiza glabra (Mulhati plant)



Rauvolfia serpentina is a typical example how a country could lose established foreign markets because of lack of promotional cultivation efforts. Its cultivation techniques are fairly known yet no sizable plantation has come up in the country. The African plant *R. vomitoria*, which now meets the bulk supply of the industry, is a large shrub and is yet to establish its credentials as a field crop. *Cephaelis ipecacuanha* yield *emetine*, having large outside demand; its cultural requirements are known but still its commercial cultivation is restricted to a limited tract in the West Bengal. *Digitalis lanata*, which yield *digoxin* and *lanatocidec*, has been found to grow successfully at a number of temperate localities in the country; less than a decade ago, the Government of India licenced three pharmaceutical companies for production of 108 kg of these cardio-glycosides. But lack of indigenous cultivation continues to compel the industry to import our requirements in toto. *Psyllium* husk and *Senna* leaves and pods, produced in about 15,000 ha area and exported for a value of Rs 2.5 crore annually, have established themselves as safest organic laxatives, with rising popularity in the western countries. We have to expand their cultivation further to meet the additional demand. The indigenous production of *ergot* alkaloids and salts now has increased considerably since commercial production of *ergot* sclerotia on rye has come up at chakrohi farm in Jammu district.

The position of essential oils production is not very much better. The export of oil of sandalwood is showing a slow decline; a curious disease called spike disease of sandalwood continues to take a heavy toll of mature trees. The production and trade of oil of lemon grass has declined from 1000 tons a decade back to the present level of 200 tons with Guetamala pushing its produce in the world market because of better quality and lower price. We are slowly losing our hold on *Palmarosa* oil market because of our inability to meet the increased demand; Indonesia, and now Brazil are coming up with its regular plantations while we mainly distill the wild growing grass. The fusarium rot of *Geranium* and nematodea ttack on *Patchouli* do not allow these crops to expand to large areas.

Indian *Celery* seed has built up a large market demand and its export has reached a value of Rs 2 crores last year. Lately, there has been reports of delays in export and some marketing malpractices, which enabled Israel to enter the markets in Germany and Italy. There has been a steady progress in extension of cultivation of *Java citronella* grass in Assam and Mysore state effecting reduction in import of its oil while local consumption has simultaneously been increasing. Remarkable progress has been achieved in the indigenous production of mint oil (ex. *Mentha arvensis* var. *piperascens*) in Tarai Districts of Utter Pradesh (1500 ha) and the imports have successfully been brought down from nearly a crore of ruppees about four years ago to a level of Rs 45 lakhs last year. Supporting research in improvement of agro-cultivation practices, weed control and distillation techniques might enable India to enter the export market; our oil samples have been assessed to compare with some of the superior quality of the oil produced in Japan and Taiwan and the industry has made a humble begining in 1969-70 by exporting *menthol* for a value of Rs 1 lakh.

A Few Myths

Medicinal and aromatic plants made a deep impression on our ancestors. Our religious books, legends and epics stand testimony of plants emiting intoxicating, penetrating scent or miraculous healing properties invariably coming from hills. This has led many of us to think of commercial cultivation in hills, their 'natural abode'. This is not wholly true. The Central Indian Medicinal Plants organization has drawn up a priority list of these crops and has estimated that 65 per cent of the 22,000 ha land that these crops additionally need, have to be found in the sub-tropical and tropical India.

Farmers often ask me to suggest some medicinal plants or aromatic crops for their land which does not grow cereal crops well or are located beyond the pale of irrigation. An impression has inadvertently come to stay that these crops do not make specific demand on soil or irrigation; nothing could be farther from truth. Each individual medicinal and aromatic plant species has its own specific requirement of soil, climate, irrigation and fertilizers and this should be given serious consideration in planning their cultivation to obtain expected returns.

Opinion is sometimes expressed in certain influential quarters that vegetable drugs may be on the way out with advancing popularity of sulpha drugs, synthetics and antibiotics. This is not true. Crude drugs and herbal medicines, no doubt, are steadily being replaced by their active constituents, patent medicines and gelanical preparations. This should naturally be welcome because of their speedy transportation and selective action in the body in comparison with the powdered herbs or herbal extracts. Thus the several thousand patented medicines and gelanicals used widely all over the world invariably contain a number of vegetable drugs each in their formulations. As such, the total demand of vegetable drugs has been increasing manifold both in quantity and value. There is no reason to nurse apprehensions of possible fall in their demand in the foreseeable future.

Perfumes and perfumery materials go with aristocracy in India. These are however common articles of day to day use in afluent societies of Europe and America. About 280 million dollars of natural essential oils and allied perfumery material is purchased by developed countries of the world annually (excluding countries of Eastern Europe for which figures are not available) and India's share in the trade is 1.6 per cent. The world demand for new perfumery material and essential oils having differences in content and note is rising and these items fetch higher remuneration. We could push export of *Davana* (*Artemisia pallens*), *Panari* (*Pogostemon cablin*), *Costus* (*Saussurea lappa*), *French basil* (*Ocimum basilicum*), *Khus* (*Vetiveria zininioides*) and floral perfumes like *Jasmine*, *Champaca*, *Nag-Kesar*, *Keora*, *Acacia* and many other similar oriental flowers by commercial cultivation, aggressive marketing and conscious quality control. But we have to stop regarding these common things as articles of luxury and start their cultivation and production as export oriented crops.

Remove These Deficiencies

There has been little organised effort made in India to collect and maintain germplasm of drugs and essential oil bearing plants. We lack such collection even for those crops which show a wide distribution in the country or are under cultivation for a pretty long time. Improvement of these crops for higher yields, shorter growing period, increased active principles, resistence to pests and diseases could be made when the desired traits are known to occur in the parent plant material. Variability in the germplasm is prime necessity for an improvement programme and this is needed to be built up.

There is consistent lack of agencies responsible for commercial production, testing, certification and distribution of superior, viable seed and planting material. The position is still difficult in cases where live planting material (rooted slips, stolons, tubers, etc.) require long distance transportation. The Central Indian Medicinal plants organisation has been doing this work now for a few selected species grown at their farms.

The subject for medicinal and aromatic plants does not form part of curriculum for graduate or post-graduate studies. There is a dearth of trained personnel for manning these plantations undertaking research work. In fact, this has been one reason for Agriculture students not choosing those crops for their doctorate and post-doctorate work. This matter was discussed recently at the working group meeting on Medicinal and Aromatic Plants set up under National Commission on Agriculture. It was recommended that these crops be taught as a specific course in the curriculum in Agricultural Universities.

Cultivation of drugs and aromatic plants has an element of risk because the produce is priced on presence of active principles. Lack of testing facilities nearby make the farmer apprehensive of the price and long storage sometimes invite losses in its vitality. Added to it is the attitude of user industry in asking for larger lots. There is therefore a genuine need for establishing a central agency which could provide speedy testing facility for the produce at nominal price, and having revolving funds for purchasing from small farmers at a prefixed price on advice either from industry or markets abroad.

Resources Survey, Research Inputs and New Discoveries

There is increasing interest in the acquisition of new plant material as source of industrial raw material. It is almost always easy to develop a natural plant extract than to synthesise a complicated molecule in the laboratory. Experience suggest that natural material still serve as a better model even for new and possibly improved synthetic drugs. Governments and Pharmaceutical firms in the western countries organise extensive survey of potentially rich geographical regions within their country and outside. Several hundred thousand dollars are being spent annually on the screening of plant resources and the results in many cases have been rewarding. During the second world war the scarcity of belladonna alkaloids compelled commonwealth countries to search for an alternate source; this led to the discovery of *Dubosia myoporides* followed by another plant *D. leichardii* in the rain forests of Australia. *Physochlaina praealta* is another plant from Ladakh (India) which is found to give similar alkaloids; commercial collections are being made both in Australia and India to augment belladonna resources for pharmaceutical industry. The discovery of *cortisone* as a remedy in rheumatoid arthritis in 1949 led to a world wide search for plants containing *cortisone* or other similar compounds which could be converted into it. The search led to discovery of the cortico-sterioids containing *Dioscorea composita* from Mexico, and of *D. floribunda* from Central America. Similar hunt in India found *D. deltoidea* (Western Himalayas) as a very rich source of *diosgenenin* (3 to 5 and sometimes up to 10 per cent) in 1958 and of *D. prazeri* from Eastern Himalayas. Another Indian plant *Solanum khasianum* var. *Chatterjeanum* has also been discovered to contain up to 5 per cent of *Solasodin* which could be converted into the steriod hormones. *Hecogenin* (for production of Steriod hormones) is discovered in leaves of *Agave veracuze* , *A. sislana* and *A. cantal* which could be grown in alkaline soils with ph up to 8.5.

The search for new drugs pays huge dividends. The discovery of *reserpine* group of alkaloids from an Indian plant *Rauvolfia serpentina* in 1952 as a cure of high blood pressure and certain forms of insanity, made headlines in world newspapers; and the steady decline of supplies of *Rauvolfia* roots from India obliged American and Swiss Pharmaceuticals to make a world wide survey of *Rauvolfia* species. They laid their hands upon a still richer source in roots *R. vomitoria* found throughout the central Africa. The total alkaloid contents in samples collected from Senegal, Uganda and Congo vary from 0.2 to 3.0 per cent. The Rose Periwinkle (*Carthamus roseum*) from West Indies has been found to contain several tumour suppressive compounds and at least one of them is marketed by a pharmaceutical company for use in certain forms of human cancer. Anti-leukemia properties have also been located from alkaloids extracted from *Podophylum paltatum* and *P. hexandrum*. An African plant *Phytollaca decandra* is reported to have yielded a new snail killing compound. *Berberine* salts are recent addition in modern medicine and an Indian firm is manufactturing *berberine sulphate* and allied salts with Japanese Collaboration from several wild occuring species of *Berberis* in the lower hills of Uttar Pradesh. Despite the fact that most of the plant preparations have been shown to be worthless in curing dandruff and baldness, the extract of *Centella* (*asiatica*), *Swertia* and *Sopora* species are popular in hair tonics as restorer of falling hairs. The sale of the later product of Japanese origin is reported to have exceeded a sale value of 27 million dollars in 1961 in the U.S.A. alone suggesting enormous potentials of trade in herbal formulations, even in the most advanced countries of the world.

Indian scientists have also made their contribution in this field. A cardio-glycoside *peruvoside* has been isolated from leaves of *Thevetia nerifolia*, considered safe in oral prescriptions. *Hyathine* has been isolated from a twiner called *Cissampelos pareira*, which is reported to be a good substitute of *tubocurarine* (muscle relaxant) imported into the country. Isolation of *fatamansone* from *Nardostachys jatamansi* is a remarkable discovery for prolonged hypotensive activity. Extracts from leaves of *Tylophora indica* has been found to give relief in asthma. *Hersaponin* from *Herpestris moniera* is found as a promising new tranquiliser. A succulent twiner *Cissus quadrangularis* is found to reduce healing period considerably. Clinical trials have brought out the anti-cancerous properties of an Indian plant *Ervatamia heyneana* from Western Ghats and *oleoresin* from *Balsamodendon mukul* is found to lower the cholesterol level of the blood.

Most of these discoveries in India have come from the herbal medicines prescribed in the Ayurvedic system of treatment. The country spends 1.6 per cent on research out of its annual turnover of about Rs 200 crores of pharmaceuticals (against 6 to 7 per cent spent in most western countries) and ninety-eight per cent of this expenditure is made on chemical, pharmacological and clinical trials leaving researches on cultivation and improvement of these plants for their growing as field crops high and dry. This is the main reason why most of these spectacular discoveries in the field of pharmaceuticals in India have yet to be translated to manufacturing stage. The commercial production would be feasible only when we begin to give equal attention on

TABLE 1. IMPORT OF MAJOR VEGETABLE DRUGS, ALKALOIDS, ESSENTIAL OILS AND AROMATIC CHEMICALS IN INDIA

Crude Drugs	*Drug part*	1968-69 Rs	1969-70 Rs	1970-71 Rs
Mulhati (*Glycyrrhiza glabra*)	Dried roots	1323133	636099	328510
Cubebs (*Piper cubeba*)	—do—	221058	172282	80549
Galangal (*Alpina galanga*)	Rhizomes	295064	131214	533924
Pyrethrum (*Chrysanthemum-cinerariaefolium*)	dry flowers	410913	n.a.	346251
Ayurvedic herbs	miscellaneous	326894	678037	632529
		2577062	1617632	1921753
Alkaloids and other derivatives				
Atropine sulphate, Hyoscymine, etc. and allied alkaloids (ex. *Atropa belladonna* etc.)		8087	121153	100494
Ephedrine alkaloids & hydrochlorides. (ex. *Ephedra gerardiana* and allied species)		479079	1805532	4328913
Theophylline alkaloids, salts and derivatives (ex. *Theobroma catoa*)		248454	325274	309866
Ergot and its salts (ex. *Claviceps purpurea* on rye)		1054353	472979	551275
Caffeine (ex. *Commellia sinensis*)		739169	127120	
Opium alkaloids (ex. *Papaver somniferum*)		n.a.	73372	31306
Other vegetable alkaloids		2707721	2967571	6673252
		50,36,863	59,92,994	11995106
Essential oils		1968-69	1969-70	1970-71
Patchouli oil (ex. *Pogostemon cablin*)		1133518	341754	972634
Anise oil (ex. *Pimpinella anisum*)		144726	129973	90778
Bergamot oil (ex. *Citrus aurantium* var. *bergamia*)		795337	552624	784929
Citronella oil (ex. *Cymbopogon winterianus* and *C. nardus*)		890365	1704392	1297559
Clove oil (ex. *Syzygium aromaticum*)		639414	544428	935308
Geranium oil (ex. *Pelargonium graveolens*)		975891	1413526	1243313
Lavender oil (ex. *Lavendula officinalis* and other spp.)		777291	541480	785426
Peppermint oil (*Mentha arvensis* var. *piperascens* and *M. piperita*)		6823282	5499907	4561683
Spearmint oil (ex. *Mentha spicata*)		566449	434975	118984
Cajuput oil (ex, *Melaleuca leucadendron*)		13561	32040	15260
Caraway oil (ex. *Carum roxburghianum*)		8745	19060	18516
Cinnamon Leaf oil (ex. *Cinnamomum zelanicum* and *C. tamala*)		49968	101883	163368
Lemon, Orange and Petitgrain peal oil (ex. *Citrus spp.*)		243255	176440	118984
Ylang ylang oil (ex. *Canaga odorata*)		404996	372427	245722
Miscellaneous minor essential oils		289792	320279	2321051
Resinoids		664154	705008	468178
		14430724	12691404	14022713

Aromatic Chemicals (partly also by conversion from other natural aromatic material)	1968-69	1969-70	1970-71
Menthol (ex. *Mentha arvensis* var. *piperescens*)	3362363	153198	12059
Citronellol (ex. *Cympopogon winterianus*)	n.a.	27843	840
Geraniol (ex. *Pelargonium graveolens* & other spp.)	7026	45560	51847
Rhodinol (ex. *Pelargonium graveolens*)	35221	88964	222464
Cinnamic alcohol (ex. *Cinnamomum* and other spp.) and Cinnamic aldehyde	313910	315771	413874
Terpineol (fraction of oil of *Turpentine Citrus* and many other oils)	935783	1072534	1335533
Linalol (ex. *Bursera delpechiana* and other spp.)	106519	392453	121279
Linalyl acetale (—do—)	770367	468516	427283
Vanillin and ethyl vanallin (ex. *Vanilla planifolia*, also synthetic)	276295	1577733	1746570
Isoeugenol (ex. *Ocimum* spp.)	150268	25726	77223
Thymol (ex. *Thymus vulgaris*, but mainly by conversion of fraction of oil of *Eucalypus divens*	166779	474042	825800
	6314531	4621980	5228632
Grand Total (Imports)	2,83,58,980	2,49,24,007	3,31,68,214

* n.a. figures not available.

TABLE 2. EXPORT OF MAJOR DRUGS AND PERFUMERY MATERIAL INCLUDING ALKALOIDS AND ESSENTIAL OILS FROM INDIA

Crude drugs	1968-69	1969-70	1970-71
Psyllium husk (ex. *Plantago ovata*)	18303336	13849058	25465615
Psyllium seeds (—do—)	1067413	1212288	2031380
Senna leaves and pods (ex. *Cassia angustifolia*)	5918026	5705047	5443018
Cinchona bark (ex. *Cinchona officinalis* and allied spp.)	199125	408138	52245
Kuth roots (ex. *Saussurea lappa*)	831351	1587326	950316
serpentina roots (ex. *Rauvolfia serpentina*)	344792	739245	188760
Ayurvedic herbs (Miscellaneous species)	705441	405733	753690
Ayurvedic medicines (herbals)	1242202	1746494	1920564
	28611686	25653529	36805588

Alkaloids, Salts and other derivatives	1968-69 Rs	1969-70 Rs	1970-71 Rs
Qunine sulphate including other salts (ex. *Cinchonna officinalis, C. ledgeriana* and other spp.)	9311815	7724684	7669382
Emetine alkaloids, Salts etc. (ex. *Cephaelis ipecacuanha*)	599094	1001845	546219
Strychnine alkaloids (ex. *Strychnos nux-vomica*)	564398	888383	584591
Brucine and other nux-vomica (ex. *Strychnos nux-vomica*) salts	764595	722278	1152222
Papaverine and their salts (ex. *Papaver somniferum*)	35200	—	—
Rauvolfia alkaloids (ex. *Rauvolfia serpentina*)	38618	13638	34567
	11315720	10350828	9986981

Perfumery material	1968-69	1969-70	1970-71
Celery seeds (ex. *Apium graveolens*)	8061094	14182580	20201690
Cinnamomum bark, leaves (ex. *Cinnamomum zeylanicum* and *C. tamala*) and flowers	3101928	5464040	2523778
Dill seeds (ex. *Anethum graveolens* var. *sowa*)	619098	1200426	1376528
	11782140	20847046	24101796
Essential oils			
Sandal wood oil (ex, *Santalum album*)	31488091	27476235	24540335
Lemon grass oil (ex. *Cymbopogon flexuosus* and allied spp)	5293466	10511099	7799766
Palmarosa oil (ex. *Cympopogon martini* var. *motia*)	3700329	2576180	2495688
Vetiver oil (ex. *Vetiveria ziziniodes*)	197986	297820	236364
Ginger grass oil (ex. *Cympopogon martini* var. *sofia*)	69400	16796	70534
Keora oil (ex. *Pandanus odoratissimus*)	n.a.	380817	178881
Other essential oils (Miscellaneous)	2293821	1562831	2439108
	43143733	43838585	37591198
Grand Total (Export)	9,48,53,279	10,06,89,988	108485563

their agricultural research. There is a direct bearing between research inputs and industrial production. The U.S.A. annually spends 365 million dollars on research and development on all aspects of the pharmaceutical industry and a recent survey suggest that it (USA) has discovered 67 top fast selling drugs since 1950 which enabled it to pay back all its expenses in few years of marketing these drugs.

Crop Research

Crop research is a continuous process which enables release of improved plant stock and cultivation devices to cultivators. The present state of our knowledge of these crops leaves much to be desired. Scientists at Regional Research Laboratory, Srinagar have found presence of certain inhibitory substances in the seed coat of belladonna, their removal by treatment with petroleum either or ethyl alcohol has given significant improvement in germination. Soaking of *datura* seeds in ethyl alcohol has been found to increase alkaloid content of their foliage. A new mutant of belladonna, capable of giving commercial yield is being developed at Bhaba Atomic Research Centre, Trombay. Breeding work in *Psyllium* at Indian Agricultural Research Institute, New Delhi and National Botanic Gardens, Lucknow., has given superior line of plants with bold seeds; the total seed yield, however, has not shown corresponding increase. A fast growing cultivar of *Dioscorea composita*, with a total *diogenin* content of 3.03 per cent is reported to be isolated at Indian Institute of Horticultural Research, Bangalore.

In the field of essential oil crops, the development of a tetraploid in Japanese mint about a decade back at Jammu containing 5 per cent oil (zero moisture) in the leaves has been a significant work; the planting stock of this colchiploid, it is hoped, would now come in the hands of the cultivators. Screening trials at C.I.M.P.O. farm, Haldwani has led to the finding of 'Sinbar' herbicide effective in control of weeds in Japanese mint and peppermint crops; another significant work at the farm is the isolation of a high yielding cultivar of *dill* with large-sized fruiting umbels. Lemon grass Research Station Oodakaly (Kerala) has developed a strain of lemon grass called as OD 19 which gives larger herbage and oil yield than the existing plant type and is being distributed to cultivators.

Work on cultural requirements of certain medicinal and aromatic plants is under study at a number of research stations in India. The information on different aspects of their cropping and processing, however, is scattered in various research journals. An attempt has recently been made to bring out consolidated information in form of extension articles on Ipecac, Senna, Rauvolfia, Celery Palmarosa, Java Citronella, Dhoop, Jasmine, and Japanese mint in this journal (and *Indian Horticulture*) and such articles covering Belladonna, Foxglove, Psyllium, Glycyrrhiza, Linaloe, Geranium, Patchouli, Eucalyptus (citriodora), Vetiver, Dill, Davana, Keora and others are being presented in the coming issues of these journals.

Co-ordinated Project

There has been a continuous appraisal of research programme and planning by Agricultural council on all major crops in India. The Council has hitherto been supporting research schemes on different aspects of medicinal and aromatic plants in agricultural universities, central and state research laboratories and state agriculture departments. This has not been considered enough; it was therefore planned to organise research work on these crops during the Fourth Five Year Plan period by establishing research stations in different agro-climatic regions of the country. The agricultural research on most of the important crops are now organised under All-India Co-ordinated projects and the integrated, multi-disciplinary approach invested in these projects has proved useful in bringing together the work done at different agricultural universities, research organisations in partnership on all India basis. The research work on medicinal and aromatic plants has therefore been re-organised under an "All India Co-ordinated Improvement Project on medicinal and aromatic plants." Two main centres for research are being developed at Central research institutes (viz. I.A.R.I., New Delhi and I.I.H.R., Hassarghatta, Bangalore) while three sub-centres are being established at H.P. University, Solan, Cinchona department, Dodabetta (Ootacamund) in Tamil Nadu and Agriculture College, Junagarh in Gujarat State. It is hoped that the staff will soon be in position at most of these institutes.

A programme for work has been finalized under the Co-ordinated Improvement Project which broadly includes collection and maintenance of germplasm, improvement studies by various means, developing agro-techniques and chemical evaluation of the crop and marketable produce at various stages of growth and in storage. To begin with, Belladonna, Foxglove, Glycyrrhiza, Henbane, Pyrethrum, Psyllium, Rauvolfia and Senna have been selected as medicinal plants for detailed investigations. The essential oil bearing crops selected for work under the project include Anise, Celery, Java, Citronella, Geranium, Mints, Palmarosa oil grass, Patchouli and Vetiver. It has been decided that additions and modifications in the programme could be discussed and finalized periodically in the all India workshop meeting on these crops to make it an integrated, collaborative and co-ordinated programme.

A Bright Future

The attainment of near self-sufficiency in major cereal crops in the country has brought industrial crops to the forefront. The new method of relay cropping and higher inputs demand new cash crops that could fit in the cropping pattern of irrigated lands. There is increasing awareness amongst cultivators for accepting new crops for higher economic returns. The demand for seed, planting material and details of package of practices and marketing in medicinal and aromatic plants are increasing fast. This is welcome. The efforts made in popularising cultivation of Japanese mint in Uttar Pradesh and of Java citronella grass in Assam and Mysore suggest enormous possibilities of expansion in cultivation and production of basic pharmaceuticals, intermediary and end products. With expansion in research efforts for evolving high-yielding varieities and new cost cuttings crop management and processing devices, there could be reasonable assurance of an expanding production and trade in these commodities in the country and their export. These are labour intensive enterprises that could absorb a part of the surplus man power available in the rural countryside.

Mr. Edward Corcoron and Mr. R.W.J. Slee have been commissioned by U.N.I.D.O. to advise the ministry of foreign trade (Govt. of India) on ways and means to increasing exports in field of essential oils, perfumery, toiletries, cosmetics and ancillary products and on drugs and pharmaceuticals respectively. These experts have recently submitted their reports. Amongst other things, they have emphasied that almost every type of soil and climatic conditions are available in this country to make the production of plant based industries a paying industry. "Commercially, the big problem of the future will be to bring down prices, which can only be done by improving yields both by growing and distilling". Mr. Corcoran has recommended a three-pronged approach "to get as much increased export as possible from raw materials, intermediate materials and end products" for increasing the exports to a value of a hundred crore rupees by the middle of the next decade.

PHOTOS

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—Editor

FERTILIZER USAGE IN CHANGING AGRICULTURE IN PUNJAB

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FERTILIZERS constitute an important input for increasing agricultural production and they play a key role in intensive farming. The importance of fertilizers in green revolution has been well-appreciated by the cultivators as well as all others concerned with agricultural production. Today, more than ever, the farmers have considered using more fertilizers to build up the fertility status of land and thereby increasing production levels.

The contribution of fertilizers in increasing agricultural production has been very well-demonstrated in this country and elsewhere. A comparative study made for Second Five Year Plan period (1956-61) revealed that in India, fertilizers contributed in increasing agricultural production to the extent of 45 per cent, while other factors like irrigation, improved seeds, double cropping and land reclamation measures contributed only 27,13, 10 and 5 per cent respectively. In a study made in the U.S.A. it was found that fertilizers constituted the largest single factor in increasing total crop production there and accounted for 50 per cent increase in yields. A series of trials conducted by Food and Agriculture Organization of United Nations in 14 different countries in the world have established beyond any doubt that substantial increases in yields of crops can be obtained by use of increased doses of fertilizers even if no other technical factor is changed.

The role that fertilizers have played in increasing wheat production in the state of Punjab is equally convincing. Total wheat production in the Punjab state in the year 1961-62 was 1.76 million tonnes and it has increased to 5.15 million tonnes in year 1970-71. Similarly, fertilizer consumption here increased from 49,162 tonnes in 1961-62 to a figure of 1.5 million tonnes in year 1971-72. Recent studies conducted for evaluating relationship between fertilizer consumption and yield of wheat in nine different districts in the state showed that correlation coefficient values between these two parameters ranged from 0.840 to 0.904 revealing that 70 to 80 per cent increase in wheat yields in the state can be ascribed to increased use of fertilizers alone.

Increasing Use of Fertilizers

During the period of expanding usage of fertilizers in increasing agricultural production in the state of Punjab, the demand for fertilizers has always exceeded the supply.

It is evident that consumption of fertilizers in the state has been increasing rather rapidly. It is estimated that from the current level of 1.5 million tonnes, the fertilizer consumption in Punjab will touch a figure of 2.9 million tonnes in the year 1973-74.

Comparison for consumption of fertilizers per unit agricultural land in Punjab with other states in India show that consumption of fertilizers in the Punjab during the early sixties was among the lowest but with time, the consumption has increased and currently the fertilizer consumption in the Punjab is highest in the country. With the intensive agriculture being followed in the state, the fertilizer use will expand further and its consumption in the state will favourably match with that in many advanced countries in the world.

In early sixties, ammonium sulphate, CAN, superphosphate, muriate of potash were the only fertilizer materials being used in the Punjab. With the passage of time when increase in agricultural production was envisaged, new forms of fertilizers have been introduced and the farming community here has already experienced the use of different high analysis and chemically pure fertilizers like urea, ammonium sulphate, nitrate, triple superphosphate, ammonium phosphate, diammonium phosphate, urea ammonium phosphate, ammonium phosphate sulphate, nitrophosphates, etc. A stage has reached in the state that the cultivators here prefer to use compound and complete fertilizers over low analysis straight fertilizers.

It is evident that in the fertilizer usage, emphasis has already shifted from single nutrient use to all the three nutrient elements use. It is satisfying to note that the trends in use for N.P.K ratio is improving. Efforts are being made that the ratio attains the ideal value of 4.2.1 desired for the country though the world targetted ratio is 1.1.1.

Impact of High-Yielding Varieties on Nutrition Problems

Stress on Soils. Introduction of high-yielding varieties of crops ushered in a new change in the agriculture pattern in the state. Local indigenous varieties cultivated earlier needed less nutrients, were not much responsive to fertilizers and did not put much stress on soil for nutrients. On the other hand, dwarf varieties respond much to fertilizer additions, are known to have higher nutrient requirements and their cultivation exhausts the soil heavily for nutrients.

Studies conducted in Punjab on wheat and maize under irrigated conditions of cropping reveal that large quantities of nutrients are removed by these crops from the soil every year and total removal of nutrients depends on variety and yield level. It is evident that in cultivation of high-yielding varieties, even if soils are basically rich in nutrients, they cannot afford to meet such heavy demands of nutrients of high-yielding varieties year after year, unless the requirements are supplemented by additional use of fertilizers.

High Nutrient Requirements. Since the introduction of high-yielding varieties of crops, large number of field experiments have been conducted in the state to evaluate their responses to the application of nitrogen, phosphorus and potash. The results indicated that high-yielding varieties responded more to application of nitrogen than local indigenous ones. With an optimum dose of 120 kg N/ha, dwarf varieties of wheat gave good to high responses ranging from 7.01 to 13.37 q/ha with an average of 10.41 q/ha. The responses obtained with phosphate application were generally of lower order than those to nitrogen and ranged from 2.36 to 5.53 q/ha with an average of 4.05 q/ha. With N dose of 120 kg/ha, each kg N resulted in increasing yield of wheat by about 8 kg grain and each kg P_2O_5 with a dose of 60 kg (in conjunction with N) increased yield by another 13 kg grain.

Phosphorus becomes the Limiting Nutrient. The results of experiments conducted on responses of nutrients during the year 1969-70 and subsequently showed quite reverse of what was observed earlier. It was found that high-yielding varieties of wheat responded much less to application of nitrogen but responses to phosphorus application were of high order. Slight to moderate responses to application of potash were also observed. Responses per kg N with application of 60 and 120 kg N/ha were 12.5 and 9.2 kg grain in Sonalika and 13.4 and 9.4 kg grain in Kalyansona. The responses per kg P_2O_5 with application of 30 and 60 kg P_2O_5/ha were 18 and 11 kg grain in Sonalika and 11 kg grain in Kalyansona.

Since nitrogen application gave high responses, in cultivation of high-yielding varieties of cereals, use of nitrogenous fertilizers had become more common. The cultivators continued adding only one nutrient element nitrogen and no attention was given to the simultaneous additions of phosphate and potash for balanced manuring. Cultivation of high-yielding varieties of wheat without ensuring proper use of phosphate contributed to inducing phosphate deficiency in soils. The results of trials conducted during 1965-67 had revealed that among two varieties (C-306 and PV-18), high-yielding Mexican variety accumulated more P in both grain and straw indicating that dwarf varieties required higher P and if P is not applied in their cultivation, soil would soon be depleted of its P supply.

Experiments conducted in the Punjab have shown that in the cultivation of high-yielding varieties, under the condition when no phosphate is applied to crops, it takes just 1 to 2 crop seasons for a soil with normal supply of phosphorus to get depleted to a level at which crops cannot be produced satisfactorily unless application of P to the soil is ensured. Differences in cropping systems and intensity of cropping also resulted in bringing about phosphorus deficient conditions in the soil and thus phosphorus has become the limiting nutrient element in soils of Punjab.

Zinc in the List of Limiting Nutrients. The conditions wherein only macro-nutrients are used as in put year after year for obtaining high yields of crops resuls in exhaustion of reserves of micro and rare nutrients in the soil. With the exploitive nature of agriculture being followed in the Punjab, micronutrients in soils are becoming limiting. Use of chemically pure and high analysis fertilizers has increased the incidence of deficiency of micronutrietns in these soils. After spectacular yield responses in high-yielding varieties of wheat to nitrogen, followed by phosphorus, now zinc has been added to the list of nutrient elements limiting yields.

During the last 2 to 3 years, at a rather large number of sites in the state especially in light textured soils and under intensive cultivation practices, normal growth of high-yielding cereals could not be obtained inspite of mineral fertilization with recommended doses of N, P and K. Our on-the-site investigations and field demonstration trials have shown that in all such cases, nutrient element zinc was the limiting factor for production.

Application of $ZnSO_4$ at the rate of 50 kg ha in soils showing deficiency by soil test or by deficiency reports resulted in increasing the yield of wheat grain from 2.0 to 13.4 q/ha with an average increase of 5.0 q/ha. In other words, application of zinc increased the yield potential varying from 13 to 76 per cent over yields obtained with application of NPK alone in zinc deficient soils. The detection of deficiency of zinc in soils as the additional limiting factor has contributed significantly in practical farming in the Punjab and cultivators have been able to maintain yield levels.

While spectacular responses to zinc application have been obtained in high-yielding varieties of crops, differential behaviour of different varieties to varying deficiency of zinc have also been evaluated. Based on zinc content in 3rd leaf from top following tentative grouping for wheat crop have been suggested:—

less than 8 ppm zinc—acute deficiency
8-12 ppm zinc—moderate deficiency
12-16 ppm zinc—hidden deficiency
more than 20 ppm zinc—lack of response

A Case Study for Fertilizer use' Nutrient Problem and Yield production. IADP district of Ludhiana in the Punjab state has recorded the highest consumption of fertilizer nutrients—130 kg/ha against the state average of 75 kg/ha for the year 1971-72. Similarly, the yield of wheat recorded in this district is the highest, viz. 34/q ha against 22.5 q/ha for the whole state.

A critical appraisal of the trends in fertilizer use in relation to wheat yields in this district indicate that yields here have not been keeping pace with the increase in fertilizer consumption. For example, the yields continued to rise till the year 1968-69 and in the year 1969-70, the yields declined appreciably (from 34 q/ha to 30 q/ha).

Our investigations show that among others, the most important factors found responsible for this decline were disturbance in the balance between various nutrients and deficiency of nutrients other than, N,P, and K. When corrective measures to control both these factors were adopted, not only the yields could be brought back to the original production level but also the prediction value for relation between fertilizer use and wheat yield improved from 80 to 83 per cent.

A similar type of situation is found to exist for the whole of Punjab state. Summary of results of over 200 experiments conducted have clearly shown that yields of cereals in the state during last few years have been declining and this again is due to the fact that some limiting factors in soil has become operative. Widespread deficiency of zinc has already been observed in the state and other deficiencies may show up in future. We have therefore to be always looking for nutrient deficiencies and other soil factors which may become limiting and reduce the production level.

Appreciation for Soil Testing Service. The basic fertility status of the soil can be best determined by using soil testing as the tool. Soil tests also detect presence of any other abnormal condition in the soil that may affect the plant growth and crop production. From farmers' point of view, soil testing is important, since it determines not only the relative nutrient supplying power of the soil but also provide information for making a decision on application of fertilizers with reference to type of material, dose, time and method of application.

In the growing agriculture technology in the Punjab, the role of soil testing has been well appreciated. In the year 1957-58, there was only one soil testing laboratory was added at Gurdaspur in 1967-68. These two soil testing laboratories are managed by Punjab Agril. University. For providing benefits of soil testing service to all the farmers in the state, more soil testing laboratories have also been set up by Marketing Federation and State Department of Agriculture and it is heartening to note that at present there is at least one soil test laboratory in each district in the state.

Fertilizers applied on the basis of soil test values give high yields and are most economical. If the soil is deficient in nutrient supply, higher doses are required to be applied but on the other hand if the soil is rich, low doses can produce maximum yields. A series of field demonstrations laid in the state have shown beyond any doubt the benefits of applications of fertilizer on soil test basis.

To make the utility of soil testing service more rewarding, need has been realized to develop soil test recommendations for different crop sequences rather than for one particular crop, as at present, There is also a need to quantify fertilizer use targetted for different yield levels and tailored to well-defined soil groups occuring in the state.

Future Needs

Fertilizer Use in Relation to Quality of Produce. So far the main emphasis in use of fertilizers has been solely for increasing yield production of crops. Fertilizer use must also be viewed for the quality aspect of the produce as well. Quality of food and fibre determines the health of our nation and cattle. It has now become essential that the fertilizer use as related to quality of produce receives urgent attention in this country. It may also be mentioned here that in a number of advanced countries in the world, quality aspect has already become important and while fixing the price of produce, quality is given due weightage.

Experimental evidence exists to show that quality of the produce can be improved by balanced nutrition of crops and protein content in the cereals can be manipulated by adjusting the applications of nitrogen. Recent studies conducted in Punjab reveal that quality of wheat can be improved by balancing the nutrition of crops with zinc as well. It has been found that application of zinc at 5 ppm level resulted in increasing fat (ether extract) and calorific values of grains of wheat, maize and paddy, in addition to increasing the carbohydrate content in rice and maize and protein contents in wheat and maize.

With the achievement of self-sufficiency in food production in the country, rightly enough during the

Fifth Five-Year Plan, emphasis is being shifted to animal production and animal products. Such a change is desirable particularly when diversification in agriculture is required. The role that soil fertility and fertilizer use has to play in this changed strategy cannot be underestimated. Information is to be collected on the quality of forage and relate the same with soil conditions and health of the cattle, since many ailments in animals are purely due to excess or deficiency of certain nutrient elements in the forages.

In the Punjab a number of reports have been received where feeding of IR.8 paddy straw to cattle in some areas has led to deterioration in health of animals and the cause of this is attributed to the unusually high content of some heavy elements in IR.8 paddy straw. Knowledge of such nutritional disorders are to be monitored and information related to soils and their characteristics.

A sample survey conducted for low-lying, water submerged areas in the basins of rivers in the Punjab has revealed that about 21 per cent of the berseem (*Trifolium alexandrinum*) fodder samples contained molybdenum at toxic level (more than 10 ppm) and 34.5 per cent samples had moderate amounts (5—10 ppm) and rest 44.5 per cent samples contained less than 5 ppm molybdenum and were suitable for feeding purposes. The results of our experiments have shown that accumulation of molybdenum in forage to toxic levels can be checked by application of sulphur in the soils.

Inventory on Nutrients in Toxic Ranges. A number of instances have come up in the Punjab wherein toxic concentrations of some elements have been built up in the soil. The nutrients that need mention in this regard are boron, fluorine and molybdenum. The build up of these elements to toxic levels has been essentially due to either the nature of the soil and its environments or defective sub-soil irrigation waters.

Deterioration in soils due to the presence of such nutrient elements in toxic levels has affected not only the fertilizer use efficiency and yield production levels but also has deleterious effect on the quality of food and fibre produced. Proper care has to be exercised in making the best use of such marginal soils. Intensive researches are required to find ways and means which can counteract the bad effects resulting from presence of such toxic elements in the soils.

Pollution by Fertilizers Use. Judicious use of fertilizers is advantageous, since it increases the production levels and improves the quality of the produce. Researchers are, however, acutely aware of the possibility of adverse side effects of excessive and indiscriminate use of fertilizers on the environments. Evidence established elsewhere shows that fertilizers can degrade the land, air and water in more than one way. Among various fertilizer materials, nitrogen can easily cause pollution of underground waters, streams and lakes which in turn can be hazardous to both human and animal health.

Since fertilizer consumption in the Punjab state has increased, rather rapidly and currently the fertilizer consumption here is the highest in the country, it is high time to evaluate if heavy use of fertilizers pollutes our environments. Studies have therefore to be initiated in the state to determine the possible undesirable effects due to use of fertilizers, conditions under which the effects occurs and to know means of avoiding these effects.

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SOIL FERTILITY AND FERTILIZER USE IN INDIA

B. RAMAMOORTHY and M. VELAYUTHAM
Indian Agricultural Research Institute
New Delhi

Most of the research work on soil fertility and fertilizer use in the country before Independence was conducted at a few experimental stations. The results of these experiments indicated that many of the soils in the country would respond to nitrogen. It was soon realised that fertility status of soils on experimental farms and of the cultivators' fields was very different. The latter were much lower as fertilizer use on cultivators' fields was generally not much common in the Country at that time. Following the advice of Dr A.B. Stewart (Aberdeen, U.K.) and Dr H.N. Mukherjee (Bihar) simple trials on farmers' fields to determine their need for fertilizers was taken after Independence.

In 1952-53 with the assistance of the Technical Cooperation Mission of the U.S.A., Soil surveys and fertilizer use experiments both at experimental farms and on the cultivators' fields were taken up on an extended scale. Soil Testing Laboratories were also established by this time and on the basis of preliminary work done at the Indian Agricultural Research Institute, the soil testing laboratories began classifying the nutrient status of soils into three categories, low, medium and high. These had shown that about 80% of the cultivators' fields tested would respond to phosphorus also in addition to nitrogen.

New Trends in Fertiliser Application

In 1957 extensive trials were undertaken in a coordinated fashion all over the country, entitled "Model Agronomic Experiments on Experimental farms and Simple Fertilizer Trials on cultivators' fields". These results tended to show that the correlation between soil tests and response to fertilizer was not statistically significant in the simple fertilizer trials. In 1960 the programme of package of practices and intensive agricultural development programme were taken up in the country with the assistance of the Ford Foundation. Some of the Soil Testing Laboratories have been strengthened in these I.A.D.P. districts. *Ad-hoc* adjustments of fertilizer doses based on soil test were propagated. According to this the fertilizer doses as evolved from the Agronomic Experiments for any crop in any region were recommended for all soils testing 'medium' in respect of nutrients, N, P and K. These doses were reduced by 30 to 50% according to local experience if the soil test values of the fields were 'high'. The fertilizer doses were increased by the same 30 to 50% whenever the soil test values of the fields were 'low'. A number of follow-up trials on cultivators' fields called the A.B.C. trials were conducted including A) the farmers' current practices of using fertilizers, B) the fertilizer dose as recommended from the agronomic experiments and C) the fertilizer dose adjusted as above on the basis of soil test. Numerous such trials conducted all over the country showed that the fertilizer recommendations based on agronomic trials in any region were much more remunerative than the existing farmers' practices. These recommendations based on soil tests were on

FIG. 1a. PROFITABILITY OF FERTILISER USE FOR ECONOMIC RESPONSE OF WHEAT AT DIFFERENT PLACES

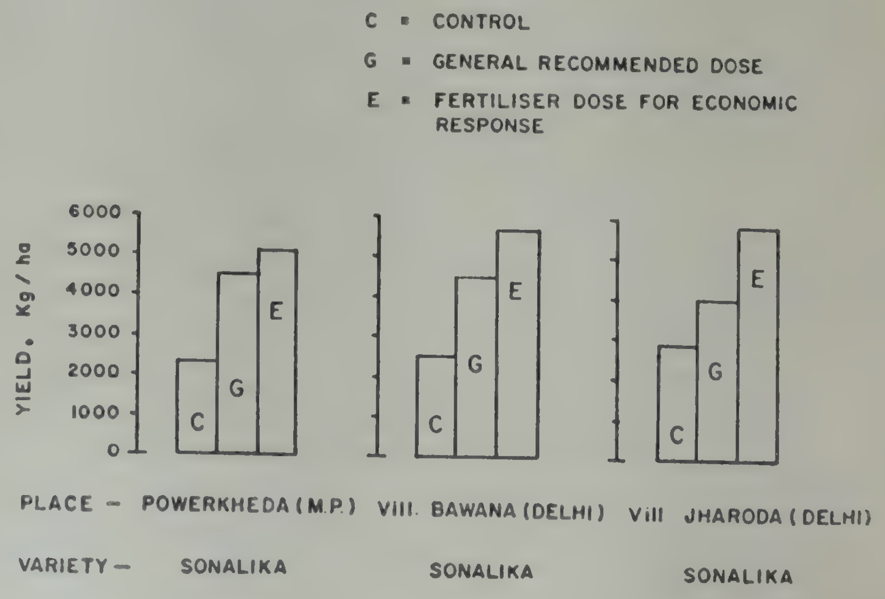
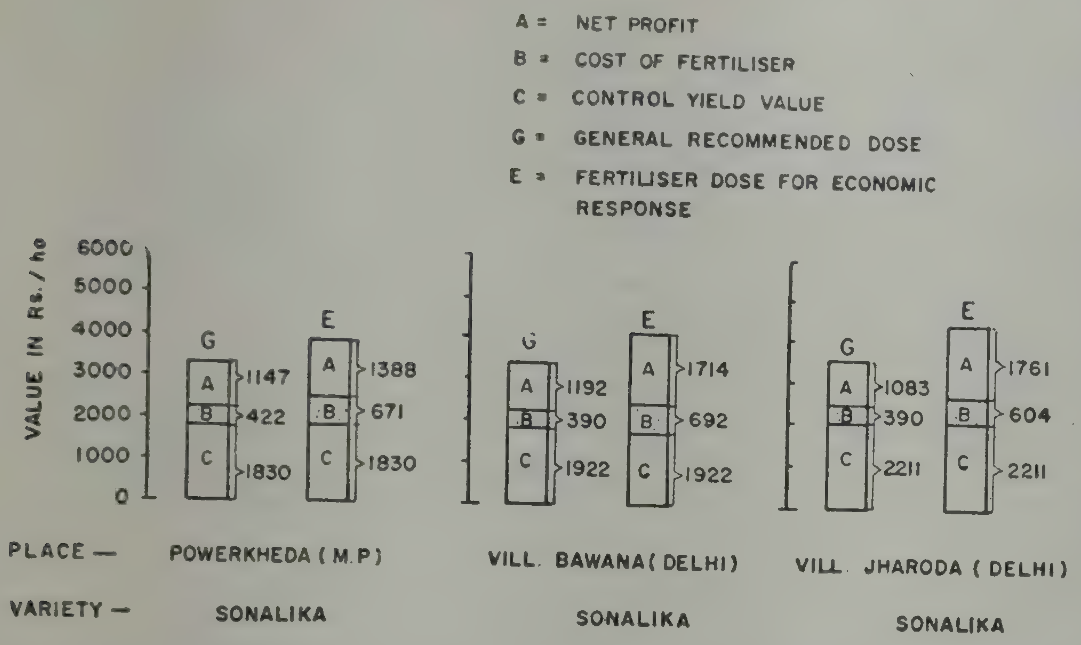


FIG. I b. PROFITABILITY OF FERTILISER USE FOR ECONOMIC RESPONSE OF WHEAT AT DIFFERENT PLACES



the average found to be 11% superior in net profit to those based on agronomic trials as reported in World Soil Resources Report No 41 (P.98) of the F.A.O.

In 1961-62 some research work was also started at the Indian Agricultural Research Institute to correlate crop responses with soil tests from complex experiments conducted at experimental farm of the IARI with the tall varieties of wheat on one and the same field in which various plots differed considerably in their soil test values. This showed highly significant correlations between soil test values and crop responses. It was also found possible from the response function to calculate fertilizer doses for highest yields of wheat varieties NP 718 and NP 824 as reported in *Indian Farming* (Feb. 1966).

Soil Testing and Fertilizer use for High Yielding Varieties. With the introduction of the high-yielding varieties similar experiments were conducted with these varieties during 1965-67 which also showed statistically significant correlation between soil tests and crop responses with high-yielding varieties of wheat and bajra besides yielding data for making fertilizer application for targetted yields of crops as reported in the *Indian Farming* (August, 1967). The regression equation also enabled the derivation of optimum fertilizer doses for these crops. This work enabled the planning of the research programme of an All India Coordinated Scheme on Soil Test Crop Response Correlation in order to obtain a basis for adjustment of fertiliser doses for varying soil test values of farmers' fields and remove the arbitrariness in recommending fertiliser doses as currently adopted by the soil testing laboratories. It was felt by then that with the older variety requiring generally about 30, 20 and 20 kg/ha N, P_2O_5 and K_2O, the 30 to 50% adjustment was all that was feasible because it was not practical to apply fertilizer doses under farmers' conditions in less than 10 kg/ha. But with the high yielding varieties requiring generally 120, 60 and 40 kg/ha of N, P_2O_5 and K_2O and with the same unit of fertilizer application being practical in the farmers' fields, it was no longer economical to adjust by the above mentioned *ad-hoc* methods. The rates of fertilizer doses to be applied to these crops require greater accuracy in fertilizer adjustment to soil tests in order to make them as economical as possible.

National Programme of Soil Test and Crop Response Correlation Studies. With the experience gained from the preliminary work referred to above from the IARI and conscious of the difficulties met with in seeking significant correlation between the soil tests and crop responses from the simple fertilizer experiments condu-

FIG. IIa. PROFITABILITY OF FERTILISER USE FOR ECONOMIC RESPONSE OF RICE AT DIFFERENT PLACES

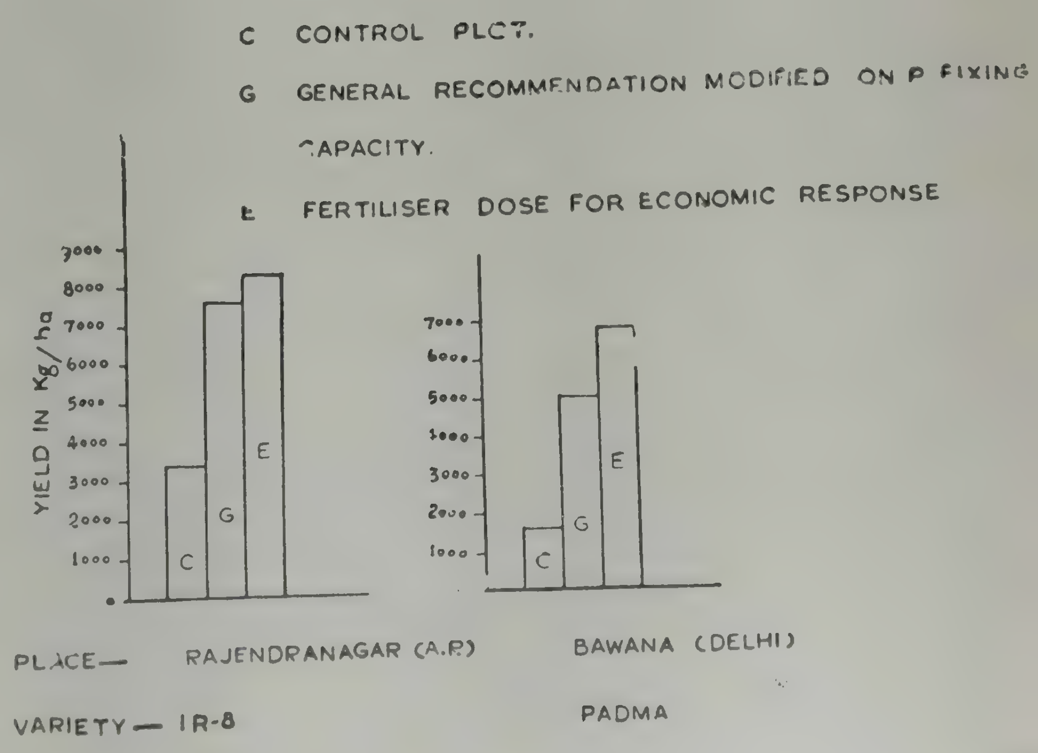
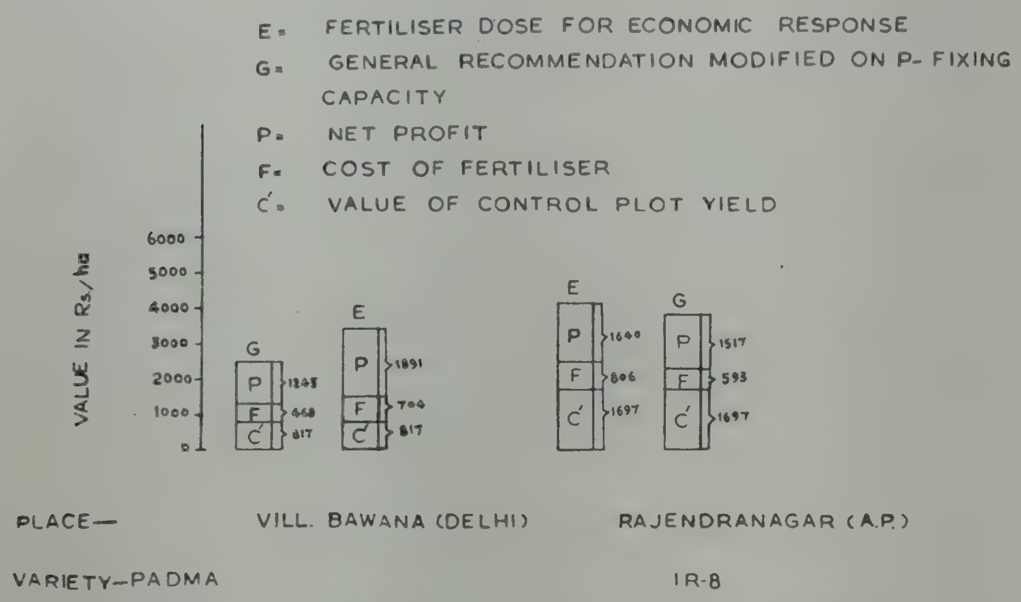


FIG. II b. PROFITABILITY OF FERTILISER USE FOR ECONOMIC RESPONSE OF RICE AT DIFFERENT PLACES.



cted in the country, a special national programme was drawn up to meet the specific requirements of above mentioned situation in the country. The special feature of this programme is that all the variation in soil fertility level needed for correlation was obtained not by selecting soils in each one of the field experiments carefully conducted at a few selected centres typical of different agro-climatic regions in order to ensure homogeneity in soil population, management practices and climate. From this work was determined not only the optimum fertilizer dose but also the economic fertilizer dose needed for maximising the profit/ha from the investment on fertilizer. The predictability of the regression equations which formed the basis deriving the adjustment equations between soil tests and fertilizer doses was as high as 76% in many of the Centres and their sub-centres which now total up to 24. Such fertilizer adjustment equations are available for N, P and K for wheat (Kalyan Sona) for Grey Brown and Chestnut soils of Ludhiana and Gurdaspur; Sonalika for black soils of Jabalpur and Powerkheda and alluvial soils of Delhi; Rice IR.8 for black soils of Rajendranagar, and alluvial soil of Delhi, Ranaghat and Bikramganj and red loams of Kanke and maize (Ganga Safed 2) at Kanke. The work involved in this scheme also provides information on the suitability of current soil test methods under field conditions for the various soil type and high-yielding varieties of crops. This attracted the interest of many of the Soil Scientists in the country who volunteered to take up the programme of the scheme even without financial assistance from the Indian Council of Agricultural Research.

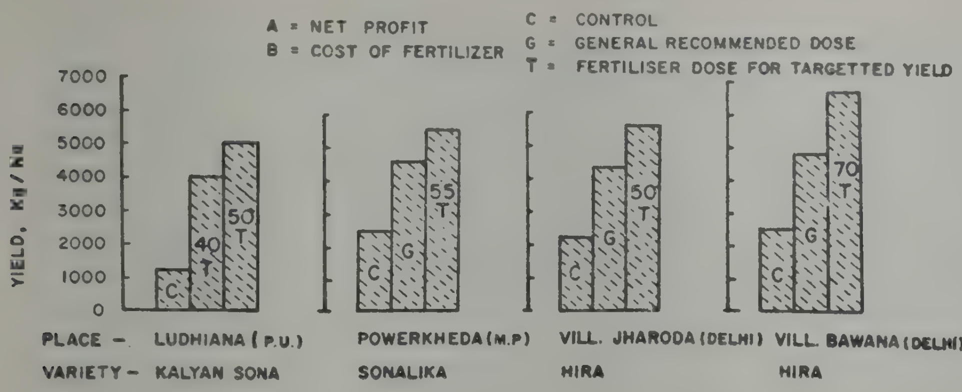
High Yields with High Profits

It was envisaged that the results obtained at these carefully selected centres would be extended to cultivators' fields falling in the same soil-agro-climatic region as that of the experimental site through a series of follow-up experiments both on the experimental farms and on farmers' fields.

Fig. Ia and Ib show some of the results of the follow-up trials on wheat conducted in Delhi villages and Powerkheda in Madhya Pradesh with wheat Sonalika at which the economic fertilizer dose (E) adjusted for the soil test values of the field chosen, as derived from the scheme on soil test crop correlation was compared with the general fertilizer dose (G). They show that the net profit/ha on fertilizer use at Powerkheda on the basis of the economic dose derived from the scheme is Rs 1388 as compared to Rs 1147 on the basis of the general agronomic dose. The corresponding profits at Bawana village are Rs 1714 and Rs 1192 while at

Fig. 11-C. Economic response dose—IR 8 at Ranaghat (W.B.)

FIG. III a. ECONOMICS OF TARGETTED YIELDS OF WHEAT AT DIFFERENT PLACES



Jaroda village these are Rs 1761- and Rs 1083 respectively. Thus it is possible with the help of the economic dose not only to get higher profits, but also higher levels of crop production which were 5117 kg at Powerkheda, 5696 at Bawana and 5875 at Jaroda as against 4472, 4611 and 3989 kg/ha respectively for the standard agronomic dose.

The trials conducted on rice at Bawana village and Rajendranagar (Figs. IIa and IIb) similarly show that higher net profits are also obtained at these places alongwith higher yields. These are Rs 1891 with yield of 6825 kg as against Rs 1245 with yield of 5000 at Bawana village. Then net profits at Rajendranagar are Rs 1640 with yield of 8256 kg/ha as against Rs 1517 with yield of 7623 obtained even after general agronomic dose has been modified on the basis of P-fixation capacity of the soil. The stand of the rice crop IR.8 under the economic fertilizer do seat Ranaghat (W.B.) is shown in Fig. IIc.

Future Trends

a) *Integrated Soil Test Crop Response Correlation Studies.* It is also felt in extending the results of the experimental stations to farmers' fields that it was necessary to have information as to how the yield and response to fertilizer is affected by variation in many other soil properties like physical conditions, extent of salinity, etc, For this purpose a pilot study on integrated soil test crop response correlation was taken up at IARI in which the yield and response to fertilizer were related not only to soil test values for N, P and K and fertiliser doses but also to physical properties like bulk density or extent of salinity and alkali conditions of the soil. The delegates to the FAO-UNDP Seminar for Soil Survey and Soil Fertility Research in Asia and Far East Asia, held in New Delhi in February, 1971 who visited these experiments recorded their observations as follows as given in the World Soil Resources Report No. 41. P.5, F.A.O. Rome :—

"As a general recommendation arising from this discussion it was proposed that part of the "Research in the Seventies" should be directed towards the quantification of crop requirement in terms of soil nutrients, water, soil physical properties and other soil management variables on the lines of the pilot field experiment at the Indian Agricultural Research Institute at New Delhi, which the delegates were shown on the Integrated Soil Test Correlation and which is being included in the All India Coordinated Scheme on this subject. It was suggested that this information is necessary for a range of crops to establish the feasibility of various multiple cropping patterns and that these would provide a valuable guide for soil surveyors in the future."

b) *Fertilizer Application for a Whole Crop Rotation Based on Initial Soil Tests.* The integrated soil test crop response correlation studies which are expected to be undertaken in the next phase of the programme alongwith intensified follow-up trials on farmers' fields will help in translating the results of experimental centres for the benefit of a large number of farmers in making fertilizer use both for profit and for high levels of crop production causing a significant agricultural transformation in India.

This would, however, require that the soils be analysed before the sowing of each crop which will not be possible for the soil testing laboratories to do for all the farmers. There is need therefore for making similar recommendations for a whole crop sequence based on initial soil test values alone. This requires not only a knowledge of economic dose of fertilizer and the crop yields expected from a given crop on the basis of not only soil test values but also the expected soil test values after the harvest of the first crop so that the latter could be taken as initial soil test values for the second crop in order that the

FIG. III b ECONOMICS OF TARGETTED YIELDS OF WHEAT AT DIFFERENT PLACES

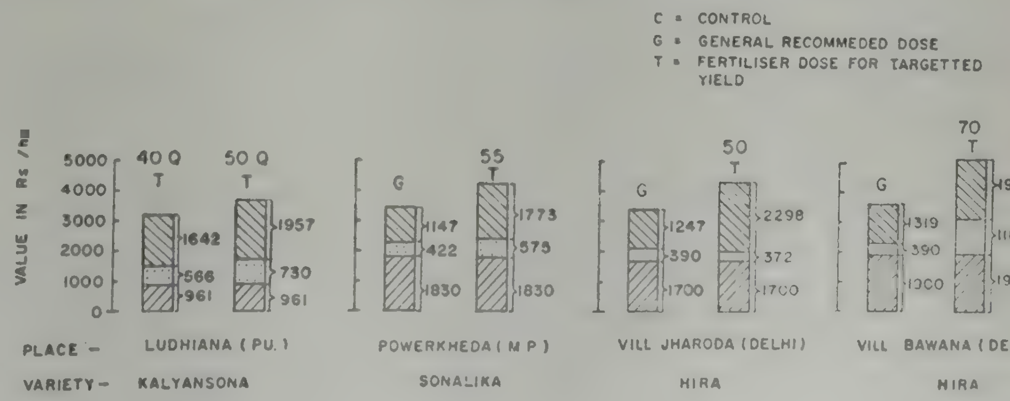
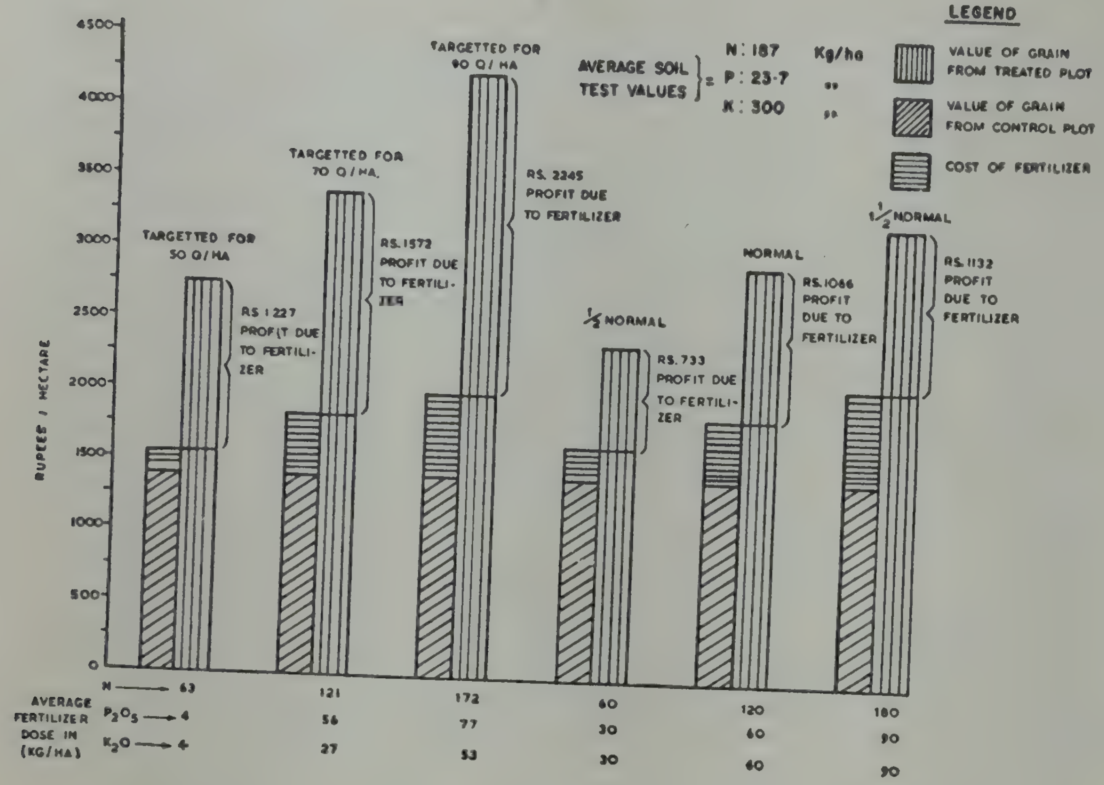


FIG. IV. ECONOMICS OF FERTILIZER USE FOR RICE (IR-8) FOR DIFFERENT YIELD TARGETS AT I.A.R.I., FARM.



economic fertilizer dose for this could be determined from the knowledge of the existing soil test crop response studies. A beginning has been made in this direction at the IARI as reported in *Indian Farming* of September, 1971. Work has also been started for soil test crop response correlation studies on various other fibre, oilseed and pulse crops that are commonly occurring in multiple crop rotation.

c) Follow-up Trials on Targetted Yields. Work has also been recently taken up at many Centres in follow-up trials on fertilizer application for targetted yields which was initiated in 1966 at the IARI. This approach is based on the determination of the nutrient requirement per quintal of grain production which was found to be nearly constant for the same variety irrespective of soil and seasonal conditions, the contributions of nutrients from the soil as percentage of soil test values which was found to be constant characteristic of the soil and the agro-climatic region and the percentage of utilisation of the applied fertilizer by the crop which was also found to be nearly constant characteristics of the soil-agro-climatic region and the method, time and form of the fertilizer nutrients applied in balanced usage.

A number of experiments done at Delhi both under experimental farm and cultivator's conditions have shown that with this method, yields obtained were within 10% of the yield targetted. Fig. IIIa and Fig. IIIb show the extent to which these targets have been achieved as well as their economics at different centres, Ludhiana (Punjab), Powerkheda (Madhya Pradesh) and Jaroda and Bawana in the Delhi State. These show that at Powerkheda (Madhya Pradesh) the yield target of 55 q/ha was achieved satisfactorily with net profit on fertilizer use of Rs 1773 as against a profit of Rs 1147 for the general fertiliser dose which yielded 44.7 q/ha of Sonalika. At Ludhiana (Punjab) 48 Quintal/ha was obtained for the 50 quintal that was targetted yielding a profit of Rs 1957 as against Rs 1672 for the general agronomic fertilizer dose. In the Delhi villages also targetting of wheat showed good agreement, production being 65.1 quintals as against 70 targetted, yielding a net profit of Rs 1988 as against Rs 1319 obtained for the general agronomic fertilizer dose which yielded 47.8 quintals. Similar results were also obtained at the Jaroda village.

d) Fertilizer Use For Profit For Small Farmers. It has been found that there are many situations in the country in which the farmers are unable to apply the full dose of fertilizer recommended either as general agronomic dose or the economic dose as indicated above. Pilot studies conducted at the IARI have shown that targetting for lower yields would be more paying to the small farmers than arbitrary slashing of the agronomic dose of fertilizer recommended as shown in Fig. IV. It was found that the net profit on fertilizer dose with rice targetted for 50 quintals was Rs 1227 as against Rs 733 obtained by slashing the standard agronomic dose by 50%.

The country therefore is set on self-reliance in carving research suited to its special needs or transforming Indian Agriculture through profitable fertilizer use based on soil testing.

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Co-ordinated Agronomic Experiments

Soil Fertilizer and Soil Test Crop Response Studies

N. N. GOSWAMI and I. C. MAHAPATRA *

The All India Coordinated Agronomic Experiments Scheme aims at developing location specific agro-techniques for maximising production per unit area per unit time, for different crops and cropping systems under different crops and cropping systems under different soil and climatic conditions obtained in the country through a series of experiments at the experimental stations (model agronomic centres) and to further assess and adopt the technology developed at the model centres under cultivators' field conditions through experiments popularly known as simple fertilizer trials. Obviously, these techniques should relate to fertilizer requirements for different crops and crop rotations and the soil characteristics for the centre or the area to which these results are intended for recommendations. The soils and other chemical aspects of study are mainly (i) survey, classification and characterization of the soils of different model agronomic centres, study of the physical, chemical and physio-chemical properties of the soils in relation to crop production and study of the uptake of nutrients by different crops and (ii) study of the relationship between soil test and crop responses to fertilizers, since the main aim of this project is to develop a package of practices for maximising production through efficient use of fertilizers.

The genesis and progress of soil studies in this scheme can be broadly divided into four distinct phases.

First Phase (Prior to 1969)	Lack of serious work, realizing and assessing problems
Second Phase (1969-70)	Making a good beginning, removing limitations
Third Phase (1970-71)	Intensive studies, introduction of new approaches
Fourth Phase (1971-72 onwards)	Extensive implementation

In this article only the progress of work on soil fertility has been reviewed. The detailed results have been published elsewhere (Goswami *et al.* 1971a, 1971b, 1972).

First Phase

Until about 1969 soil studies had not been given any serious attention to the extent it was necessary and desirable in view of their importance in adequate interpretation of the yield data obtained in the project. This is evident from the fact that although 8,000 trials on cultivators' fields were conducted during 1968-69, hardly about 3500 trials had supporting data on soil analysis. Similarly, even after quite a few years of experimentation at the model centres, basic soil data were not available. First attempt in the right direction was made in the year 1969 with the creation of the 'Soil Science Unit' at the Project Headquarters at IARI to look into these limitations and take appropriate action to remove them. Until then, there had been practically no serious effort to relate the fertilizer responses to soil tests in spite of the fact that the main theme of this project had been to evolve fertilizer recommendations for different crops under different soil situations, besides the fact that the progress of soil research not only suffered a great deal from quantity point of view but also in quality which is actually more important. This situation is explained with the help of results presented in Table 1 which show that the simple correlation coefficients (r) between soil tests for phosphorus and yield were found to be extremely low and non-significant, indicating thereby that there was little association between the soil content of the nutrient and yield response, which is a very wrong conclusion indeed and defeat the very purpose which a production soil scientist would look and work for.

Further, multiple correlation coefficients taking a number of soil factors such as pH, organic carbon, available N, P and K into account also showed that the value of correlation coefficient (R^2) could explain the variation only to the extent of 30 per cent. Thus the first phase of soil research in this project gave a very disheartening note. However, a deep look and thought into the factors under which the trials were conducted would explain the reasons for this dangerous situation. These are: (i) the crop varieties were not uniform in all the trials (ii) other agronomic and management factors also varied from trial to trial (iii) no standard and uniform methods of soil analysis were adopted in case of all the trials and thus there were reasons to believe that there was scope for improving the accuracy of the soil analysis data. Since yield is dependent on a number of other factors, environmental and management, the former consisting of climate, physiography, quality and quantity of irrigation water as well as physical, chemical, mineralogical and microbiological properties of the soil and the latter including varieties, sowing and transplanting time, spacing, time and method of application of fertilizers, insect pest and weed control; a myriad of such variables might be operating under the conditions the simple fertilizer trials were being conducted then.

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*Senior Soil Scientist and Project Coordinator respectively

It was thus recognised that since more often than not a large number of these factors are uncontrolled, apparently therefore the soil test-crop response correlation could not possibly be obtained under cultivators' field conditions until the large number of variables affecting yield are reduced to the minimum, being limited only to the uncontrolled variables. It was also felt necessary to obtain data of high precision and accuracy by using standard methods for soil testing.

Second Phase

In the second phase of development, serious thought was given to improve the chemical aspect of the work both in quantity and quality and at the same time the quality of the field experiments with regard to the crop management was considerably improved. The programme of work at the model agronomic centres included (i) survey and classification of soils of model agronomic centres into distinct soil series based on profile studies and other soil characteristics, (ii) study of the physical, chemical, physio-chemical and fertility characteristics of the soil and (iii) study of the uptake of nutrients by different crops. While complete information on soil survey could not be obtained due to lack of adequate facilities, existing information as available from the central and state soil survey organizations were collected, the other programme of work was carried through. In the simple fertilizer trials every field where a trial was laid out on cultivators' fields were sampled and analysed for the fertility characteristics of the soil. They were scrutinised and soil test summaries and nutrient indices for different nutrients such as N, P and K were computed for the different simple fertilizer trial districts and the relationships between soil tests and crop reponses to fertilizers were worked out. Through this it soon became evident that phosphorus was as limiting as nitrogen, and potassium was also deficient in many areas in the country. Thanks to the introduction of high-yielding varieties, improved agro-techniques and emphasis on soil analysis that it was soon possible to identify the areas where more than one nutrient was limiting crop production. This itself was a very big leap forward in soil fertility and fertilizer-use research in the country. Soil test-crop response relationships were worked out using the data of simple fertilizer trials on cultivators' fields. It was observed that a 'r' value of the order of 0.7 was obtained for wheat. 'Critical level' for phosphorus could be worked out for certain crops and soils (Table 2).

TABLE 1. SIMPLE CORRELATION COEFFICIENTS BETWEEN SOIL TEST FOR PHOSPHORUS AND YIELD RESPONSES

District	*Crop (Variety)*	*Degree of freedom*	*'r' values*
West Godavari	Rice (IR-8)	45	—0. 26
Alleppy	—do—	18	+0. 09
Coimbatore	—do—	57	+0. 22
Hoshangabad	Wheat (K. Sona)	35	—0. 21
Karnal	—do—	167	—0.102
Ludhiana	—do—	140	—0.144

TABLE 2. CRITICAL LEVEL FOR SOIL PHOSPHORUS AND YIELD RESPONSE OF RICE AND WHEAT TO FERTILIZER PHOSPHORUS

Soil group	*No. of trials*	*Critical level (kg P_2O_5/ha) (Olsen value)*	*Response to phosphorus (kg/ha) at 60 kg P_2O_5/ha over 120 kg N/ha*	
			Below C.L.	*Above C.L.*
		Rice		
Red				
Shimoga	25	15	2078	140
Chittoor	17	18	3187	684
Deep black				
Nizamabad	38	30	1102	711
Coastal Alluvial Alleppey	39	67	521	104
Laterite Palghat	44	18*	747	127
Medium Black Nasik	32	46	292	33
West Godavari	30	33	1954	760
		Wheat		
Alluvial Ludhiana	84	17	1839	1056
Grey brown Mehsana	59	17	788	238

*Bray No. 1 method

However, it was observed that only in about 60 to 83 per cent cases the response to applied fertilizer was related to the soil tests since only these many points were in the positive quadrants in the scatter diagram showing soil tests on 'x' axis and per cent yield on 'y' axis. It was felt that these relationships could be further improved if the trials were conducted on well-defined soils (soil series/association) and the fertilizer treatments selected were based on consideration of soil test for phosphorus and the phosphorus fixing capacity of the soil. Fertilizer requirements could then be calculated for the soils of individual fields in the locality with the available information on the critical level and yield response functions obtained from the field trials conducted with graded doses of fertilizers on soils of different fertility status.

Third Phase

During 1970-71 a pilot project on soil fertility evaluation was started within the general framework of the simple fertilizer trials programme in the districts of Sambalpur and Kanpur with rice and wheat respectively. The methodology adopted in the layout of the trials under this programme was distinctly different from that being followed in the regular SFT programme. The essence of the new programme lay in (a) careful selection of fields for fertilizer trials, based on analysis of soil samples collected from more or less well-defined soil associations, series or types, (b) conduct of the experiments on soils of different fertility status and (c) treatments based on soil characteristics. Another important feature of this programme was that the area of operation was defined and delineated by soil boundaries rather than geographical or administrative boundaries. For example, in Sambalpur the experiments were conducted in both Sambalpur Sadar I and Sadar II Blocks on lateritic and alluvial soils, which are the predominant broad soil groups in the district.

This approach had yielded very encouraging results. The responses to phosphorus and potassium were very spectacular and well related to the soil tests. Critical level for phosphorus and potassium could be worked out more accurately and they were found to be 10 ppm P for wheat in Kanpur and 100 ppm K for rice in Sambalpur respectively. It was further observed that net returns increased markedly where the phosphate or potassium application was done on the basis of soil test. For instance, in Kanpur district in 63 trials conducted on wheat on cultivators' fields it was observed that the responses were 6.5, 10.8 and 14.6 quintal additional grain per hectare for application of 60 kg P_2O_5/ha respectively in soils testing high, medium and low in this nutrient according to Olsen's method. Likewise, in case of potassium the mean response was 3.8, 4.7 and 6.8 q/ha with 80 kg K_2O/ha (tables 3 and 4).

TABLE 3. RESPONSE TO PHOSPHORUS IN RELATION TO FERTILITY STATUS

Crop *Wheat* Distt. *Kanpur* (kg/ha) Season *Rabi* 1970-71

Fertility class for phosphorus	*No. of trials*	*Yield without phosphorus ($N_{120}K_{12}$)*	*Response to P_2O_5*			*C.D. 5%*
			30	60	90	
Low–P	20	3268	948	1456	1885	251
Medium–P	27	3603	629	1079	1203	129
High–P	16	4008	570	653	689	208

TABLE 4. RESPONSE TO POTASSIUM IN RELATION TO FERTILITY STATUS

Crop *Wheat* Distt. *Kanpur* (kg/ha) Season : *Rabi* 1970-71

Fertility class for potassium	*No. of trials*	*Yield without potassium ($N_{120}P_{60}$)*	*Response to K_2O*		*C.D. 5%*
			40	80	
Low–K	27	4186	383	676	178
Medium–K	32	4353	383	468	151
High–K	4	4573	263	384	335

Fourth Phase

In view of the good results obtained in the pilot project as mentioned above, similar programme of work was taken in all the SFT districts having assured irrigation or high rainfall conditions under a new set of experiments known as type 'C' trials from 1971-72 and similarly, on the same lines type D trials have been introduced from the year 1972-73 in the SFT districts under dry farming programme. It is hoped that in the coming years type 'C' experiments in the cultivators' fields will cover all soils and crops in irrigated areas and type D in dry farming areas. The main theme of these experiments is to establish a level of soil nutrient below which fertilizer application is profitable and response to the applied fertilizer is high (critical level) for different nutrients and crops and to work out optimum fertilizer doses for soils belonging to different fertility classes namely, low, medium and high so that use of fertilizers could be rationalised.

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ADVANCES IN RESEARCH IN BARLEY IMPROVEMENT

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SCIENTIFIC work on improvement of barely crop was initiated in early twenties of this century on modest scale in different states and at the IARI (Indian Agricultura Reasearch Institute). Varieties adapted to local conditions prevailing in different states were selected. These programmes led to the release of series of varieties in different states and at the IARI. Important ones are listed below:—

Uttar Pradesh	—	C251, K18, K24, and K71
Punjab	—	T4, C138, C164
Bihar	—	BR22, BR32
Rajasthan	—	RS17
IARI	—	NP13, NP21

These varieties were superior to local types in grain yield, grain quality, earliness and in some cases tolerance to deseases. T4 and C251 were particularly valued for production of good-quality malt for brewing and were in fairly large demand for this purpose.

Recent Research

Formulation of All-India Coordinated Barley Improvement Project. The per hectare yield of barley in India during the past 25 years has remained stationary around 8–10 quintals per ha. A study of factors responsible for these low yields revealed that the varieties developed had narrow adaptability and lacked many desirable features such as lodging resistance, disease resistance and pest resistance. Further more, very little information on agronomic aspects was available.

In order to develop multi-disciplinary research on barley improvement in the country, All-India Coordinated Barley Improvement Project was organized in 1967. Under the Project, the barley growing areas in the country were grouped into broad ecological zones representing different agro-climatic conditions under which this crop is grown and eight research centres were established in these zones.

Selection of Varieties for Rainfed and Irrigated Areas of Different Zones. All-India Coordinated tests with newly developed strains were organized at a large number of locations in 1967. These tests led to release of four varieties for different zones in the Plains Region and two varieties for the Hills Region. These varieties not only gave better overall yields than checks but also maintained this superiority during individual years. A brief description of the varieties is given below:

Jyoti. This variety was developed at the U.P. Institute of Agril. Sciences, Kanpur. It has wide adaptability and was released for irrigated areas of North Western and North Easten Zones of the Plains Region. It gave 6–10 per cent more grain yield than controls. Its yield potential under appropriate package of practices is estimated at about 35 quintals per hectare. It is slightly short-statured variety with fairly good straw strength. It has medium maturity. This variety has about 16 per cent protein.

Ratna. Ratna was selected at the IARI, Delhi and has been released for rainfed areas of North Eastern Plains zone (East U.P. and Bihar). It has on an average given grain yield of 19 quintals per hectare under rainfed conditions and has excelled controls by a margin of 11 per cent. Two other very desirable features of this variety are high degree of stability—its ability to maintain fairly good yields even under unfavourable environmental conditions, and high tolerance to saline conditions. It is medium in maturity, and its grains have about 14 per cent protein.

*RS.*6. This variety was bred at Durgapura (Jaipur) and has been recommended for rainfed and irrigated areas of Central Plains zone, where on an average it has given 12 per cent more yield than checks in rainfed conditions and 18 per cent more yield than checks in irrigated conditions. Results show that this variety is capable of giving grain yield of 35–38 quintals per hectare.

Because of low protein content (8 per cent) and fairly good predicted malt extract value, RS 6 is considered suitable for production of malt for brewing.

Vijaya. Vijaya was selected at the U.P. Institute of Agril. Sciences, Kanpur. It has been found to be suitable for rainfed areas of western U.P., where on an average based on past three seasons, it has given grain yield of 26 quintals per hectare. This variety is shorter in height than normal types. It is slightly early in maturity.

This variety is being further tested for its suitability for rainfed areas of Haryana and Punjab.

NP. 109. NP109 was bred at Simla (IARI). This is a husked variety and is recommended for most of the hilly areas particularly lower hills. In trials it has given 16 per cent more yield than the local varieties. In a demonstration plot grown at the Wheat Breeding Sub-station, Simla a yield of 43.7 quintals per hectare was recorded when 60 kg N/ha was applied. NP.109 has also excellent field resistance to yellow rust which is a serious disease of barley in the hills.

*LSB.*2. At higher altitudes naked varieties of barley are in demand, and these replace wheat as a staple crop. LSB.2, a naked type developed at Bajaura, (H.P.) has been released for this region. Four years tests show that this variety is capable of yielding on an average 20 quintals of grain per hectare whereas local types gave yield of 11 quintals per hectare. This variety can also be cultivated during summer and fairly good yields can be obtained. LSB.2 has desirable grain charactersitics. Its grains are also fairly rich in protein.

Selection of Varieties With Good Malting Quality. High malting quality for brewing is governed by environmental factors as well as varietal characterstics. Bold uniform grains, low nitrogen content, medium diastatic power and high malt extract value are some of the desirable features that are essential for good malting quality. Generally, two-row types are considered to be superior to 6 row types in these characters. In India only 6–row types are grown commercially. In order to indentify 2–row types suitable for growing in India, varieties from different countries of the world that are known for their good malting qualities, were introduced and were tested at different locations. Among these Clipper, a 2–row type for Australia seems to be promising. It has maintained high malting quality when grown in India and has as well given good yields. In 1971–72, on a farmer's field of 15 acres near Gurgaon, this variety gave an average yield of 3 tons per hectare, which is comparable to the yield that is expected from 6–row types grown under similar conditions of crop growth. It is proposed to release this variety shortly.

New Approaches

Evolution of Semi-dwarf Strains of Barley. Lodging is the most serious factor limiting barley production. The Indian varieties under cultivation are tall and weak strawed, and consequently lodge even under conditions of low fertility. Therefore, programme was initiated to develop dwarf types with stiff straw.

In Rajasthan, a short-statured variety, RDBI developed through mutations at Durgapura (Jaipur) has been released. This variety has capability of yielding up to six tons of barley grain per hectare under moderate fertility levels (80 kg N/ha). This variety is now in fairly good demand in Rajasthan.

Several dwarf strains developed through conventiona. breeding methods are also under tests in the coordinated trials. Among these in the tests conducted during 1971–72, DL69 and DL70 have shown considerable promise. These have done well throughout the North Western Plains zone and average yields of 53.5 and 46.6 quintals per hectare respectively were obtained. The increase in yield over tall varieties ranged from 17 to 34 per cent. In addition both these strains are highly resistant to stripe rust in the field, which is a very serious disease. These results thus clearly indicate the high potential of new semi-dwarf types that are in the assembly line and further work with these is in progress.

Place of Barley in Multiple Cropping. In multiple cropping intensive rotations of 3–4 crops per year are adopted. In many of these rotations sowing of rabi cereals is delayed. Barley being a short duration crop, is likely to fit better than wheat. In view of this, experiments were conducted at several locations in the past two years to compare the performance of dwarf varieties of wheat and new varieties of barley under late sowings. Two dates, third week of December and second week of January, were selected and recommended agricultural practices for each crop were followed. Average performance clearly indicated that barley invariably outyielded wheat by large margins in each year at each sowing date. These results thus clearly demonstrate that barley has considerable potential in multiple cropping rotations.

Recently at the IARI three short-statured strains BM10, BM14, and BM21 have been produced through mutations. These strains in the tests conducted at the IARI matured in 100-103 days (as compared to 120–125 days taken by normal varieties), and produced 45–50 kg of grain per hectare per day under normal conditions of fertility. In addition because of shorter height these strains will be able to utilize irrigation and fertilizers more efficiently. Further work is in progress to test these strains more extensively.

Improvement of Nutritional Quality. The nutritional quality in barley, as in other cereal crops, depends upon protein quantity as well as protein quality of the grain. Cereal proteins having higher proportion of essential amino-acid, lysine, are considered to be superior from the nutritional point of view.

The upgrading of nutritional quality in barley has become possible only recently with the discovery of variety Hiproly by Swedish workers, and isolation of two mutants, Notch–1 and Notch–2 at the IARI. Results of tests conducted at the IARI for the past four years have shown that in Hiproly the protein content ranged from 16–21 per cent in different years with 4 gm of lysine per 100 gm of protein, Notch–1 and Notch–2 were relatively more stable with regards to protein content which was around 18 per cent. Notch-1 has 3.5 gm of lysine per 100 gm of protein. These strains are agronomically poor and hence can not be used directly for cultivation. They are now being extensively used in the breeding programme throughout the country for transferring desirable nutritional qualities to the released varieties.

Research In Agronomy

Performance of wheat and barley and their response to fertilization under rainfed conditions has been compared in experiments conducted at the IARI, New Delhi. Results show that barley not only gives higher yields than wheat under such conditions but also shows far superior response to fertilization. Under both fertilized and unfertilized conditions, barley gave almost twice the yield of wheat.

Performance of two newly released barley varieties, Ratna and Vijaya, at three levels of nitrogen fertilization, control (0 kg/ha) 20 kg/ha, 40 kg/ha was studied under rainfed conditions. Both the barley varieties exhibited fairly good response to fertilizer and highest yield was recorded by the application of 40 kg N/ha. However, the application of 20 kg N/ha seems to be more appropriate since it gave maximum grain in yield (2.75 /q/ha) over control.

Four methods of nitrogen application, 1/2 soil+1/2 foliar 3/4 soil+1/4 foliar, full placement 10 cm deep, broadcast and mixed, were tested at three locations. In each case the best results were obtained by the placement of fertilizers 10 cm deep. Foliar sprays did not give any additional yield over broadcasting and mixing. These results thus clearly indicated that if it is not possible to place the fertilizer, broadcasting and mixing would be the next best method under rainfed conditions.

Performance of Barley Under Saline Conditions and Response to Fertilization. Performance of barley, wheat, oilseed and legume crops was studied on saline soils with high water. Barley was found to be the most salt tolerant crop. It gave grain yield of 27.6 q/ha while for other crops yield ranged from 2.7 to 19.3 q/ha. It is intended to conduct further research work to determine the appropriate agronomic practices for barley grown on saline soils. Available data indicate that barley responds significantly up to 80 kg N/ha.

Package of Practices

Regions of Adaptation and Soils. Barley is a rabi cereal and is one of the most suitable crops for tracts having no irrigation, or limited supply of irrigation, or poor soil fertility and scanty rainfall. For saline and alkali soils this crop is a suitable choice. It can grow well on light to medium-heavy soils. Waterlogged and acidic soils are unfavourable.

Land Preparation. The land should be properly ploughed first by soil turning plough followed by 2–3 ploughings by *desi* plough or harrowing by tractor. For harvesting a rainfed crop of barley, soil and water conservation measures like deep ploughing, discing after each rainfall, levelling and bunding should be adopted during the monsoon season. This will ensure proper soil moisture status for the crop throughout its growing season. At the last ploughing BHC (10%) at the rate of 20 kg/ha or Aldrin dust (5%) at 10–15 kg/ha should be applied to the soil to protect the crop from white ants and other soil pests.

In saline areas the land should be prepared and planked and left undisturbed for about a week before sowing. This will ensure the upward movement of salts from lower soil layers to upper soil zone making the root zone relatively free from salts.

Seed. The seed of barley should be obtained from a reliable source and the recommended variety for the tract should be used.

Variety. The recommended varieties are listed below:

LSB.2 (naked) : Himachal Pradesh and U.P. hills
NP109 (hulled) : –do–
Jyoti : Punjab, Haryana, Delhi, U.P., Bihar-Irrigated areas.
Ratna : East U.P., Bihar and West Bengal-rainfed areas.
Vijaya : West U.P.-rainfed areas.
RS. 6 : Rajasthan and M.P.—irrigated and rainfed areas.

Seed-rate. For irrigated tract 75 kg seed-rate is desirable while for rainfed areas 80–100 kg depending on the soil moisture available in the growing season. For saline areas higher seed-rate (100 kg/ha) is preferred to ensure a better stand of the crop.

Seed Soaking. Before sowing, seeds of barley should be soaked in water over night at normal temperature particularly for rainfed and saline areas. This ensures better and quicker germination giving a proper crop stand (poor crop stand is a problem in rainfed and saline areas).

Method of Sowing. Seed should be dropped with the help of *pora* attached to a *desi* plough or with a seed drill so that the seed distribution at a uniform depth and spacing in a moist zone is ensured.

Spacing

Row to row	23 cm
Seed depth	4.5 cm

Time of Sowing

Irrigated crop : First and second week of November
Rainfed crop : Third and fourth week of October

Sowing time of rainfed barley should be adjusted with moisture status of the soil and the environmental temperature. There should be sufficient moisture in the soil and the temperature should not be high at the time of sowing.

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BIDI TOBACCO RESEARCH IN INDIA

G. J. PATEL*

Bidi tobacco occupies a prominent position in the tobacco production in the country, sharing about 28 per cent of the total tobacco acreage. Whereas, of the total tobacco consumption of about 250 million kg it shares 34 per cent as against 29 per cent by cigarette tobacco. Consumption of bidi tobacco has increased from about 50 million kg in 1950 to about 80 million kg in 1970, and is showing increasing trend, as in cigarettes, though not at the same pace.

Bidi tobacco is largely grown in the States of Gujarat, Mysore and Maharashtra, which fulfills the domestic demand, exports being very little. However, the chances of developing the exports appear to be brighter now than before.

Area under bidi tobacco has decreased in the States of Gujarat and Maharashtra, the total hectarage having decreased from 93,000 to 86,000 and 26,000 to 13,200 hectares respectively during the decade ending 1970-71, but the total production of bidi tobacco has increased from about 78 million kg to 100 million kg during this period. This is a phenomenal increase which is largely due to increase in per acre production in Gujarat, where research efforts have been geared to increase the per hectare production potential, to make the crop retain its competitive ability with the present day improved varieties of wheat, rice and cotton which have brought in green revolution in the country. This is evident from the per hectare production of tobacco in the important tobacco growing State in the country.

Gujarat has realised an increase of about 73% in production during past 20 years as against a 9% increase in all India production. In this context, it would be quite interesting to highlight the research efforts bringing about this reality of higher production viz. evolution of higher-yielding varieties, finding out improved cultural practices and controlling diseases and pests.

New Varieties

A variety Keliu 20 (K. 20), yielding about 12 per cent higher than the previously improved variety Keliu 49, was evolved at Anand in 1956. Due to its high yield and good quality, it became the choice variety of growers in a short time. For the first time, hybridization programme was taken up in 1948 to evolve superior varieties. More than a decade had passed to develop a variety, Anand 3 with high yield and quality. It gave about 20 per cent more yield than K. 20 The variety was officially released in 1964, but despite its high yield and quality, it could not become a choice variety of growers because it was slightly late and it took two days more in field drying after harvest.

Attempts were, therefore, continued to evolve a plant type with more number of leaves, a desirable phyllotaxy so as to expose maximum leaf area to sunshine, and resistance to lodging and leaf burn disease. Advanced breeding lines with desirable quality were crossed with "Sokhadiu" which is a more balanced plant type with good tolerance to leaf burn disease but not worthy of release because of drawbacks of leaf soilage and high proportion of sand leaves. Large number of segregants were field tested for number of years to finally select as desirable type having high yield potential, better quality, proper field curability, desirable phyllotaxy imparting lodging resistance, and resistance to leaf burn. Three improved varieties, viz. Anand. 2, Anand. 23, and Anand 119 resulting from this work, were released in 1969, after district trial testing on about 100 locations. They yielded on an average 25 to 31 per cent more than Keliu 20, the choice variety of the growers. These have high tolerance to lodging and leaf burn disease, besides having superior quality. Anand 2 and Anand 119 have become the choice varieties of farmers during a small span of 3 years, locally being named by the farmers as 'hybrid varieties'. Farmers in Nipani area have also started liking these varieties because of higher yield.

The impact of these new varieties on tobacco production in Gujarat is evident from the fact that the per hectare production of about 1125 kg in 1969-70 increased to 1300 kg in 1970-71, as against more or less the same per hectare production in the country during this period.

Of the 73 per cent increase in per hectare production in Gujarat during last two decades, the share of the improved varieties is about 44 per cent, which is quite heartening indeed.

Quality Seedlings

In a crop like tobacco, adequate supply of quality seedlings at the planting time plays a very significant role in its successful cultivation. Research work was, therefore, carried out continuously to find out better and better methods of raising nursery as well as field crop.

Of the number of problems in nursery, manuring and its schedule, amount of seed to be used for sowing, protection against damping off, nematodes and soil-borne insect pests are very important. Lack of proper

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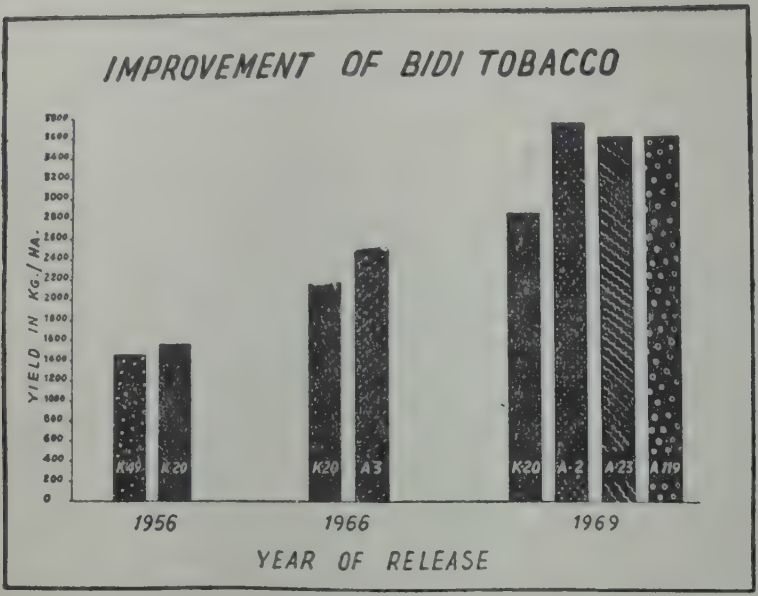


care on any of these aspects leads to failure of the nursery and thereby the field crop. Optimum requirement of manuring for nursery has been worked out by conducting number of experiments with regard to source and dosages of manures and fertilizers and time of their application. It has been found that most of the manure should be applied as basic dose and that top-dressing with fertilizers should be used in a limited way only, since, liberal top-dressing with fertilizers makes the seedlings sappy and succulent which do not stand transplanting shocks. Optimum manurial requirement for nursery is 180 kg N/ha, 45 kg N as f.y.m., 90 kg N as castor cake and 45 kg N as ammonium sulphate top-dressing. Due to high status of phosphorus and potash in the soil, application of P and K has not shown any response.

Use of 5 kg seed per hectare has been found to be the optimum under Gujarat conditions. Seed rates higher than this provide a dense population of seedlings which easily succumbs to damping off disease resulting in total failure of nursery.

After sowing, covering of seed-beds either by mango twigs or wheat straw ensures satisfactory germination even under torrential rains or scorching sunny conditions.

PER HECTARE PRODUCTION IN KG

	1951–52	1960–61	1970–71
Andhra Pradesh	772	790	602
Gujarat	745	699	1300
Mysore	398	615	488
Maharashtra	595	462	462
West Bengal	643	824	762
Bihar	934	750	1015
All India	725	763	794

Damping off of tobacco seedlings caused by soil-borne fungus is one of the most ravaging diseases in tobacco nursery. Schedule of spraying with fungicides is worked out. Depending upon the severity of the disease, it is recommended to use Bordeaux mixture (BM) 2-2-50 to 6-6-50. It is advisable and economical too to prepare B.M., the easier way which is recommended.

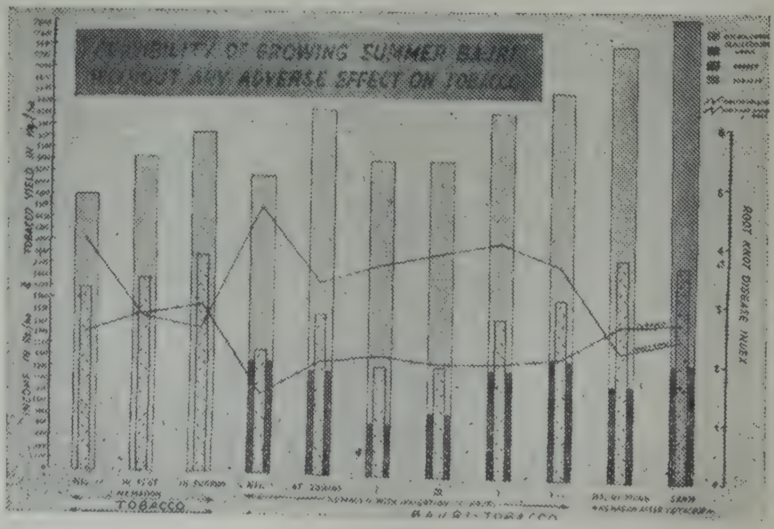
Carbaryl and endosulfan are recommended for control of soil-borne insect pests and leaf eating caterpillar. For control of root-knot nematodes, use of DBCP (nemagon), a soil fumigant, is recommended to be applied at the rate of 50 l per hectare at least two weeks prior to sowing along with irrigation water.

These research findings have gone a long way in raising tobacco nursery with confidence, under favourable or unfavourable conditions and starting of a scheme to supply seedlings to needy farmers on advance registration and guaranteed supply basis. This has become very popular among the farmers and large number of them annually take advantage of this. This has also served as a great demonstration to the farmers to raise their own nurseries and many farmers have taken up raising nursery on commercial scale.

Number of experiments were carried out since the inception of the research station, to work out an optimum and economical manuring limit, to test the efficacy of different sources of nitrogenous, phosphatic and potassic fertilizers and to increase the efficiency of manures and fertilizers.

Optimum level of manuring for bidi tobacco is 180 kg N per hectare, as the crop responds amazingly well to heavy nitrogenous manuring but not to P and K. The farmers were averse to using fertilizers for quality considerations. But research results have shown that 75 per cent of the requirements can be given in the form of fertilizers without any adverse effect on quality of the produce; if green manuring is done, even entire 180 kg

Feasibility of growing summer bajri without any adverse effect on tobacco



N can be given in form of fertilizers. This is now very widely adopted by the farmers.

Among various fertilizers, ammonium sulphate, ammonium sulphate nitrate and urea were found to be better sources of nitrogen. Application of manures and fertilizers in previously opened furrows was found to be better than broadcast application. Split applications of fertilizers was found to have no advantage.

Studies in respect of optimum planting date and plant population have shown that higher yields and better quality are realised if the crop is planted in the third or fourth week of August at a spacing of 90 × 75 cm. Planting earlier or later than this is not advantageous from yield as well as quality points of view. With regard to inter-row cultivation, the farmers have a set belief that frequent and deep cultivation is necessary for production of quality tobacco. Research findings have, however, shown that inter-row cultivation should be resorted to the extent of controlling the weeds and avoiding running away of rain water.

Improved varieties Anand 2 and Anand 119 can stand high topping without any adverse effect on quality, hence, it is recommended that they be topped at 18-20 leaves as against 13-14 of previously improved variety K. 20.

Bidi tobacco was customarily grown as a monoculture year after year. However, with a view to augmenting production of food grains, growing of bajri in summer is recommended. This brought in the problem of nematode build up which, in two or three years period of tobacco-bajri crop schedule, becomes so heavy as to make the fertile fields unproductive. To solve this burning problem, research work was undertaken to explore the possibilities of growing both the crops successfully and advantageously. Research work has shown that both the crops could be grown very successfully if DBCP (nemagon), a soil fumigant, is applied at the rate of 25 l per hectare about 15 days before transplanting of tobacco. Efficiency of fumigation can further be increased if nematode activation crops like bajri and mung are grown for about 20 days before fumigation. These findings have really paved the way for increasing the production of food crop like bajri on the same piece of land, which was hitherto utilised for growing tobacco as a mono crop. Even when no summer crop is taken, application of DBCP at 25 l per hectare has been found to increase the yield by 45%. If no summer crop is desired to be taken or no fumigation is to be resorted to, deep ploughing in summer was found to be better both for increasing the yield and minimising the nematode build up.

Three-crop Rotation

Adopting a three crop rotation in two years, viz. tobacco in kharif-rabi and bajri in summer and hybrid 4 cotton in second year has been found to give the maximum return as compared to tobacco alone or tobacco-bajri every year.

On pest control, schedules have been worked out for controlling stem borers, aphids, leaf eating caterpillars and cutworms. Studies on chemical residues are planned to be undertaken during 1972 to serve as a guide for recommending the right chemical for control of insects pest and diseases.

Research work on technological aspects has also been undertaken and a new model machine has been developed for mechanising the processing of bidi tobacco which hitherto was largely done through manual labour.

From the research work on hand and to be taken up in near future, new plant types with larger number of leaves, good curing ability and aroma resistance of leaf burn disease, tolerance to drought and also which can withstand narrower spacing and early planting are expected to be developed, which will go a long way in further increasing the per hectare production of bidi tobacco. Work on development of suitable hybrid tobacco may mark a new beginning. Incorporation of resistance/tolerance to root-knot nematodes in the improved varieties and developing cultural cum non-fumigant methods inclusive of developing a green manure crop to act as a trap crop for control of plant parasitic nematodes, when realised, will turn a new leaf in tobacco production in the country.

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RECENT TRENDS IN CASHEW RESEARCH

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THE importance of cashew came to be realized and research received due attention only recently. In fact the research on cashew can be considered to have commenced with the sanction of an *ad hoc* scheme by the Indian Council of Agricultural Research from 1951 onwards, in three States of Travancore, Madras and Bombay. Later the scheme was extended to Andhra Pradesh and Assam also. Introduction and evaluation of germplasm, production and evaluation of hybrids, floral biology studies, and propagation trials were the important items of investigations under the scheme. Germplasm collections both indigenous and exotic were established and evaluated for their yield potential and nut characters at Ullal, Bapatla, Vridhachalam, and Vengurla. Out of over 300 indigenous and exotic types screened at these centres, 10 selections and two hybrids evolved at Bapatla were found to be promising under sandy loam soil conditions of Bapatla in the East Coast.

Thirty-five varieties at Vridhachalam, six varieties and one hybrid at Anakkayam, and 4 at Vengurla were also found to be promising. They possess larger percentage of perfect flowers and higher fruit set and better quality.

Hybridisation. Hybridisation work at different centres initiated in the early 1960s yielded good results. A number of hybrids evolved at Ullal, Bapatla, Anakkayam and Vengurla are being evaluated and a few of them are found to be high-yielding with good quality nuts. Promising varieties and hybrids are being put under comparative yield trial with a view to assessing their adaptability and yield potential under different agroclimatic conditions. The establishment of a seed orchard with the promising varieties and hybrids for simultaneous evaluation and large scale multiplication of seeds has been initiated.

Propagation. The vast majority of cashewnuts are collected from trees from self-sown seedlings or from plantations raised froms seeds and seedlings. As might be expected from heterogeneous seedling population, the yield of nuts varies widely from tree to tree as also the shape and size of the nuts. Cashew apples also vary markedly in shape, size, colour and quality. Results of study in India suggest that high-yielding trees are more likely to bear nuts of medium size. In Tanzania, trees bearing large number of nuts tend to produce nuts that are too small to be suitable for the cashew trade. Because of this phenomenon less than 1% of the trees in a population are considered worthy of selection on the basis of high yield, satisfactory nut size and nut quality and only very low percentage of high yielders are reported to show uniformity in the fruit characters of the progeny. All the same, as things are at present, the only positive step that can usually be taken is to collect seeds from individual trees producing high yield of good quality nuts. The effect of raising seedlings from orchards composed of selections of superior performance is yet to be determined. A comprehensive scheme has already been drawn up to establish a seed orchard for simultaneous evaluation and multiplication of high-yielding lines. Laying out of the seed orchard with the promising lines identified at the Cashew Research Stations is in progress.

Attempts have, however, been made to standardise various methods of vegetative propagation in cashewnut. In India, approach grafting often called 'inarching' and air-layering are generally reported as most satisfactory means of propagating selected trees vegetatively. Of these, air-layering is found to be comparatively more economical. In a few comparisons that were made, air-layers and grafts have grown better and fruited earlier than seedling trees of similar age. The early yield performance was also better. However, the field establishment of airlayers was not quite satisfactory especially along the East Coast where the rainfall is low and are restricted only to one monsoon. Side grafting, veneer grafting and budding, attempted earlier, have not yielded any encouraging results. Recently, howerver, very encouraging results have been reported from Cashew Research Station, Vengurla. Both veneer grafting and breeding have been found to be successful at this centre. Veneer grafting is done in June to August and budding during September-October. With the encouraging results already achieved, a coordinated effort is being made to standardise the method under different agro-climatic conditions and for large scale field application of the technique. Side grafting was also found possible in cashew and the best takes, ranging from 35-70 per cent, were reported from Cashew Research Station, Ullal during February-May. Very high success with over 75% takes has also been obtained at Vengurla recently. Intensive study to standardise the best season for side grafting under different agroclimatic conditions and for large scale field application is in progress.

Manuring. Cashew has hitherto been considered to be as a waste land crop and not as a horticultural crop of any economic importance. It is only very recently that the importance of the crop in the national economy has been realised. As already stated earlier, increase in area has had no appreciable impact on production probably because of the inadequate attention paid for the plantation management. Preliminary trials carried out at the Cashew Research Stations have shown that there is very good response to application of fertilizers. Studies on the nutrient exhaust of cashew tree shows that the plant will absorb nutrients particularly major nutrients in very high amounts. Results of demonstration plots organised by the State Department of Agriculture with the assistance from the Central Government in the cultivators field also confirm the beneficial effect of fertilizer application and plant protection measures. Selection of planting material and adequate attention for management practice including fertilizer application, have been found to reduce prebearing age to less than two years. As this crop is grown almost in the low fertile soils and its absorption of nutrients is very high, the application of fertilizers at optimum levels is a must for getting high yield. As already indicated elsewhere, balanced fertilization could also reduce fruit fall to a great extent. Taking these factors into consideration, a comprehensive manurial trial has been planned under the Co-ordinated Project. Being a dry crop growing under very low rainfall conditions foliar application of nutrients is considered a worthwhile proposition, which will also minimise the cost of fertilization. A comprehensive trial on the foliar application of nutrient in cashew is already envisaged under the project.

Pests and Diseases

Cashew plantations are subject to the ravages of a large number of insect pests. The most destructive insect enemy is the stem borer *Plocaederus ferrugineus* the grubs of which tunnel into the trunk and kill the tree outright. The infestation can be controlled by injecting 1% Pyrethrins pipernoyl butoxide (Pyrocon-E) or carbaryl (Sevin) or application of 10 g Phorate (Thimet) granules to the tunnels in the tree trunk. Another serious pest is tea mosquito. (*Helopeltis antonii*) which sucks up sap from tender shoots, flushes, floral branches and even tender nuts. Spraying with Malathion or Phosphamidon will control infestation. Other insect enemies of cashew which have assumed importance as pests along the East Coast are the leaf miner (Acrocercops syngrama), the leaf and blossom webber (*Mecalla* sp.) and the inflorescence and shoot tip caterpillar (*Chelaria haligramms*). The leaf miner can be controlled by spraying 0.05% BHC or 0.025% Parathion and the leaf webber with 0.2% BHC or 0.03% Endrin.

The drying up of inflorescence commonly known as 'inflorescence blight' is a serious malady affecting cashew trees and causing considerable reduction in yield. This is primarily due to infestation of tea mosquito followed by infection of the fungus, *Gloeosporium mangiferae.* Earlier studies carried out at Ullal have shown that a combination spray with Cuman and Dimecron controls inflorescence blight effectively. Recent trials carried out at Kasaragod have revealed that insecticide and fungicide combination sprays with Malathion and Aureofungin Sol, Thiodan and Dithane Z-78 Dimecron and Dithane Z-78 and Sumithion and Dithane Z-78 are effective and comparatively more economical.

'Die-back' or pink disease is caused by *Pellicularia salmonicolor.* The affected portions are to be pruned and burnt and wounds protected with Bordeaux paste. Application of Bordeaux mixture 1% during the pre- and post-monsoon periods is an effective prophylactice measure. In the nursery, seedlings are affected by damping-off disease caused by *Phthium* sp., *Fusarium* sp. and *Phytophthora palmivora.* Drenching of nurseries with Ceresan wet 0.1% or Bordeaux mixture 1% has been reported to be effective.

The loss due to insect pests and disease is quite heavy in the early stages of fruit set and development. Preliminary investigations at this Research Institute show that insect attack accounts for 4.6% of shedding at mustard stage and 58% at peanut and later stages of development. In view of the fact that less than 20% of the fruit set only is carried to maturity and the indications that a very high percentage of the fruit drop is due to insect attack and imbalanced nutrition, an integrated pest and disease control schedule and the possibility of combining the pesticides with the foliar application of nutrients is being investigated under the All India Co-ordinated Project.

A good deal of work has been done at various research centres in our country, on the technological aspects of cashew. For every tonne of cashew nuts produced the production of cashew apple is about 10 tonnes. Our present estimated production of cashew apple, therefore, works out at over 1 million tonnes. Cashew apple is very rich in minerals and compares very well with other fruits in their nutritive values.

Central Food Technological Research Institute, Mysore, evolved techniques to prepare a number of edible products from cashew apple which at present is being wasted. National Chemical Laboratory, Poona, has carried out investigations on the uses to which CNSL (Cashewnut Shell Liquid) could be put to. One of the important results of these studies was the evolution of a cation exchange resin for softening water for boilers and air conditioning units. The work on the utilisation of CNSL carried out at Industrial Research Laboratory, Hyderabad, has led to a number of processes for its use in coatings. Various types of varnishes and lacquers have been formulated from CNSL and cardanol which are recommended as finishes for timber and metal, and as insulating varinishes. Rubber compounding resins prepared by compounding different types of CNSL resins with rubber, elasto-plastic sealants for cracks and joints for buildings, expansion joint filler using CNSL and coconut pith and water, and weather proof resins are some of the economic products developed.

The Morrow

Superior trees that are now being selected for seed selection are all derived from open pollination and therefore, it is possible that the progeny of such trees will continue to show wide variations in the yield and quality of nuts. It remains to be determined whether the progeny of artificially pollinated superior trees or collection of superior trees assembled in isolated orchards will yield sufficiently large crops of the quality desired by the trade and thus obviate the necessity to propagate vegetatively. In view of the limitations for adopting the vegetative propagation in cashew for raising large plantations, simultaneous evaluation and multiplication of promising lines deserve priority.

Budding is the most economical method of grafting both in terms of labour and the amount of graftwood needed. Only very recently, budding and veneer grafting have been found successful in cashew. There is an urgent need to intensify this work as well as to standardise the side grafting techniques to make it applicable on a large scale in the field. The compatibility between root stock and scion and the effect of root stock on plant type will have to be investigated in greater details.

Cashew is being grown mostly on marginal land where the fertility level is very low. Being a very heavy feeder, there is an urgent necessity to standardise the agrotechniques and work out nutritional requirement of the crop to maximise the production. Being a dry crop, feasibility of foliar application of nutrients is worth investigating. High percentage of fruit drop at the early stages of development is found to be associated with insect attack and imbalanced nutritions. An integrated pest control schedule in combination with nutrient sprays appear to be worth investigating.

At present the flowering season extends to over 4 months in plantations and the flowering period of individual trees also varies very widely resulting in very frequent harvesting of fruits. The heavy expenditure incurred for harvesting the nuts often leads to wastage of fruit. Breeding and selection to reduce the flowering phase appear to deserve due priority.

At present about 10 lakhs of tonnes of cashew apples are produced every year. The quality of fruit is comparable with any other fruit as for nutritive value is concerned. The quality, no doubt, varies very widely between trees and trees and this can easily be improved by selection. In spite of the high quality of the fruit, the percentage of fruit consumed either as fruit or for industrial purpose appears very negligible. The work on the utilisation of cashew apple for edible purpose require greater attention. The technological aspect, in general, of cashew fruit and byproducts have not received the attention it deserves.

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VEGETABLE RESEARCH AND THE CO-ORDINATED PROJECT

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DURING the Second World War, the Government of India started vegetable development schemes in different states. Since the supplies of seeds of temperate or European vegetables from abroad were almost stopped during war, attempts were successfully made to produce seeds of these vegetables at Quetta in Baluchistan during 1942-43. Almost during the same period production of seeds of temperate vegetables started in Kulu valley and Kashmir Valley. Later the Government of India established the Vegetable Breeding Station at Katrain in Kulu Valley in 1949, which was later transferred to the Indian Agricultural Research Institute in 1955. The research work on vegetable crops was intensified in 1947-48 in different States under the Vegetable Research Schemes of the Indian Council of Agricultural Research. Besides, many *ad hoc* schemes on vegetable crops were sponsored by ICAR in various States and Universities. In most of the States the work on development and research in vegetables was carried out by the Department of Agriculture or the Department of Horticulture, as Mysore State. Later after the establishment of the Agricultural Universities the work on vegetable crops was taken up by the Department of Horticulture in these Universities. Vegetable improvement was also initiated in the Division of Vegetable Crops at the Indian Institute of Horticultural Research, Hesserghatta, Bangalore after its establishment in 1968. In the year 1971 a separate Division of Vegetable Crops and Floriculture was set up at the Indian Agricultural Research Institute and a Department of Vegetable Crops at Haryana Agricultural University, Hissar. During the Fourth Five-Year Plan, an All India Co-ordinated Vegetable Improvement Project was started by the ICAR in 1970-71.

Improvement of Vegetable Crops

The improvement of vegetable crops was earlier taken up at the Indian Agricultural Research Institute and in Punjab, Uttar Pradesh, West Bengal, Maharashtra, Himachal Pradesh and Jammu and Kashmir. Introduction of varieties from abroad and testing their performance in this country and selection in indigenous varieties or local types were the initial steps taken in the breeding programme. Later hybridization was also attempted to incorporate useful characteristics from two or more sources into a variety. The main objectives of improvement were to increase the yield and improve the quality of vegetables. Unfortunately, in the beginning very little attempt was made to breed varieties resistant to diseases. However, the most significant development in resistance breeding was the release of the yellow-vein-mosaic resistant *bhindi* variety Pusa Sawani which completely replaced the other local types being grown in the country. Several other improved varieties of vegetables were evolved at IARI, and other research centres in various States. Some of the important varieties released by different research centres are listed in Table 1. Attempts have also been made to produce F_1 hybrids in some crops like tomato, brinjal, chillis, cabbage, cucumber, bottlegourd, watermelon, onion and muskmelon. A few F_1 hybrids have also been released for cultivation (Table 1). During recent years work has been undertaken on breeding varieties resistant to diseases, particularly at IARI, Indian Institute of Horticultural Research, Hesserghatta and Punjab Agricultural University, Ludhiana. A beginning has been made to breed varieties resistant to leaf curl, tobacco mosaic virus, nematodes, bacterial wilt and late blight in tomato, little leaf, nematodes and *Phomopsis vexans* in brinjal blackrot and stump rot in cauliflower and cabbage, Fusarium wilt in peas, leaf curl, mosaic and anthracnose in chillis, yellow-vein-mosaic in *bhindi* and powdery mildew in muskmelon. Sources of resistance to certain diseases have also been identified in some crops such as, *Phomopsis vexans* in brinjal, yellow-vein mosaic in *bhindi*, blackrot and stump rot in cauliflower and cabbage, Fusarium in peas, leaf curl in chillis, nematodes in tomato and brinjal and powdery mildew in muskmelon. Efforts are now being made to incorporate resistance into commercial varieties. Work has also been initiated at IARI on breeding varieties suitable for processing, such as dehydration in onion and peas and canning and juice in tomato. Besides, improvement of vegetable crops by breeding methods, experiments were also undertaken on various agronomical practices like manuring, fertilization, irrigation, mulching, distance of planting, time of sowing, weed control, etc. Unfortunately, not much consistent and uniform results were obtained in these experiments, particularly in experiments on application of manures and fertilizers. Nevertheless, some information is now available on agro-techniques in vegetable crops. Physiological studies particularly on application of plant growth regulators, starter solutions and other chemicals like boron were also taken up in some crops like tomato, brinjal, chillis, peas, cabbage, cauliflower, cucumber, bottlegourd, watermelon, etc. The results indicated the usefulness of these chemicals in increasing the yield, improving the quality of vegetables and changing the sex ratio in cucurbits. The control of diseases and insect pests also received some attention, though not on extensive scale, and effective control measures have been suggested in some cases.

Testing in Different Centres

The vegetable research in India, which has a short history of 25 years, was being conducted almost independently at various research centres. The improved varieties evolved were not tested in different agro-climatic regions. However, with the establishment of centres in different regions under the All India Co-ordinated Vegetable Improvement Project of ICAR in 1970-71 it has now become possible to test the performance of varieties in different environments and coordinate the research in vegetable crops which was lacking earlier. Under the Project there are 17 centres including 7 main centres located at IARI, Katrain, Ludhiana, Sabour, Rahuri, Hesserghatta and Coimbatore and 10 sub-centres at Kalianpur (Kanpur), Pantnagar, Udaipur, Jorhat, Bhubaneswar, Jabalpur, Solan, Srinagar, Lam and Kovilpatti. The important vegetables on which work is in progress are tomato, brinjal, chillis, cauliflower, cabbage, *bhindi*, peas, onion, watermelon, muskmelon, radish and pumpkin.

The main objective of the Project is to carry out effectively vegetable improvement research programme through coordination of multi-disciplinary efforts between States and Centre. Collection and maintenance of germplasm of various vegetable crops, facilitation of free exchange of information and seed stocks between different centres and releasing of improved varieties on regional basis along with a package of recommended practices are some of the other objectives of the Project. Breeding varieties resistant to the important diseases and insect pests of various vegetable crops have also been initiated. Special emphasis has been laid on evolving proper manurial schedules and cultivation practices by conducting regional trials. Breeding varieties suitable for dehydration and processing and having high nutritive value, have also been taken up at different centres.

During 1971-72, 65 varietal trials were conducted on various vegetable crops like brinjal, tomato, cauliflower, peas, onion, chillies, muskmelon and watermelon. The germplasm collected for 19 vegetable crops and their maintenance have been distributed among the different centres. The main centres which are engaged in breeding disease resistant varieties are IARI, Hesserghatta, Ludhiana and Sabour. Some of the diseases for which resistance is being incorporated are *Phomopsis vexans*, little leaf and nematodes in brinjal, leaf curl, TMV and nematodes in tomato, black rot and stump rot in cauliflower, yellow-vein-mosaic in *bhindi* and powdery mildew and Fusarium wilt in peas. Attempts are also being made to breed varieties resistant to fruit and shoot borer and *Epilachana* beetle in brinjal, jassids and fruit borer in *bhindi* and thrips in chillis. Agronomical trials for evolving the most suitable fertilizer schedule and spacing for the different vegetable crops are also being conducted at various centrs. Experiments on weed control in a few vegetables like tomato, onion, peas, and *bhindi* have been taken up at Kalianpur, Hesserghatta, Hissar, Rahuri and Sabour. Biochemical studies for screening varieties of peas, tomato, muskmelon, chillies, cauliflower and brinjal for their nutritive values have also been initiated at Ludhiana centre. Work is also in progress to evolve varieties suitable for dehydration in peas and onion and for processing in tomato at IARI, Ludhiana, Kalianpur and Hesserghatta.

TABLE 1

Crop	*Varieties*	*Place*
Tomato	T_1 Angurlata, Kalianpur Kuber	Kalianpur (Kanpur)
	Keckruth, Keckruth Ageti, Punjab Tropic (No. 216), S_{12}	Ludhiana
	Sl. 120, Pusa Ruby, Pusa Early Dwarf, Sioux	IARI
	H.S. 101, HS 102, HS 110	Hissar
	Sweet 72	Gwalior
	63 VF 21	Pantnagar
Brinjal	Pusa Purple Long, Pusa Purple Clustered, Pusa Kranti, Pusa Purple Round	IARI
	T_2, T_3, Vijay (F_1 hybrid)	Kalianpur
	S_4, S_5, P_8, S_1, S_{16}	Ludhiana
	H_4	Hissar
	A-61	Pantnagar
Chillis	N.P 46A, Jwala	IARI
	Kalianpur Pili, Kalianpur Surkh, Chamatkar (F_1)	Kalianpur
	G-2, G-3, G-4, G-5	Lam (Guntur)
Capsicum	California Wonder Yolo Wonder	IARI
Onion	Pusa Red, Pusa Ratnar	IARI
	Patna Red	Sabour
	Punjab Selection	Ludhiana
	Hissar II	Hissar
	Udaipur 101, Udaipur 102, Udaipur 103	Udaipur

TABLE 1. (continued)

Crop	*Varieties*	*Place*
	Kalianpur Red Round	Kalianpur
	N-53	Rahuri (Maharashtra)
Peas (Early)	Asauji, Arkel, Meteor, Early Badger, Little Marvel.	IARI
	P-12	Ludhiana
	Early December, GC 195	Gwalior
	Boach Selection	Solan (Himachal Pradesh)
(Midseason)	Lincoln, Bonneville, Early Giant, N.P. 29, Pusa Vipasha	IARI
	Banarsi Sweet, T_{19}, T_{56}	Kalianpur
	G.C. 66, G.C. 141, G.C. 468, G.C. 477, G.C. 245, G.C. 31	Gwalior
	Wando	Ludhiana
French Bean	Contender, Giant Stringless Green Pod, Pusa Parvati	IARI
Cluster Bean (Guar)	Pusa Navbahar	IARI
Cowpea	Pusa Phalguni, Pusa Barsati, Pusa Dofasali	IARI
Cauliflower	Pusa Katki, Synthetic II, Synthetic III	IARI
(Early and midseason)	Kunwari	Ludhiana
	Hissar I	Hissar
	Kalianpur Medium	Kalianpur
	Dania	Kalimpong (W.B.)
(Late)	Snowball-16 (EC 12013) Sel. 1, EC. 12012, S.C. 1, S.C. 2, K_1	IARI
Cabbage	Golden Acre, Pusa Drumhead	IARI
Muskmelon	Hara Madhu	Ludhiana
	Hyb. 1, Hyb. 2, Hyb. 3 (F_1).	
	Pusa Sharbati, S. No. 445	IARI
	Arkajeet, Arka Rajhans	Hesserghatta
	Durgapur Madhu	Jaipur (Rajasthan)
Watermelon	Sugar Baby, Asahi Yamato, Pusa Bedana (Seedless)	IARI
	Improved Shipper, Punjab Selection	Ludhiana
Radish (Asiatic)	Pusa Rashmi, Japanese White, Pusa Desi, Chetki, Pusa Himani	IARI
	HR-1	Hissar
	Sel. 271	Ludhiana
(European)	Red Round White Tip, White Icicle	IARI
Turnip (Asiatic)	Pusa Sweti, Pusa Kanchan	IARI
(European)	Purple Top White Globe, Snowball, Goldenballer	
Carrot (Asiatic)	Pusa Kesar	IARI
(European)	Nantes	IARI
Bhindi	Pusa Sawani, Pusa Makhmali, Perkins Long Green, Pusa Sel. I, Pusa Sel. II, Pusa Sel. III.	IARI
	Vaishali Vadhu	Sabour

CONTINUED FROM PAGE 90

BARLEY IMPROVEMENT

Rates of Fertilizer Application (kg/ha)

	N	P^2O^5	K_2O
Irrigated	40	20	20
Rainfed	20	20	20

The rates of application in a particular tract should be primarily governed by the soil test value.

Times of Fertilizer Application:

Irrigated : 1/2 nitrogen+full phosphorus and potash at sowing time and rest half nitrogen with first irrigation (top dressing.)

Rainfed. Full dose of nitrogen, phosphorus and potash should be placed 8–10 cm deep into the soil at the time of sowing.

Saline. Same as under rainfed conditions.

Irrigation. Number of irrigations depends upon soil types. Normally 2–3 irrigations, one at pre-sowing, second at 25–30 days after sowing depending upon soil moisture and the last near about at ear emergence, are required. Uniform distribution of irrigation water in the plot is essential. In a heavy crop of barley last irrigation should be light and should be applied when it is not windy to prevent lodging.

Weed Control. Weed problem is usually faced under irrigated conditions. Application of 2, 4–D sodium or amine salt at 0.75 kg a.e. per hectare in 700–800 litres of water 35–40 days after sowing will control the weeds effectively in irrigated areas. Under rainfed conditions the rate of herbicide should be slightly lower i.e., 0.50 kg a.e. per hectare in 600–700 litres of water.

Pest and Disease Control Schedules

A. *Soil insects:* White ants (*Odonto termes obsesus, Microtermes indicus*). Guhia weevil (*Tenymecus indicus*) cutworms (*Agrotis* spp. Euxoa spp.) Application of 5% Heptachlor or 10% BHC dust mixed with soil before planting at 25 kg/ha.

B. *Foliage pests:* Aphid (*Rhopalosiphum maidis*). Spray 0.05% methylparathion (metacid) or 0.05% fenitrothion (Sumithion), or 0.05% endosulfaon (Thiodan), or 0.03% Lindane to the foliage at 600–800 litres/ha when aphids appear. Repeat the spray at 10/15 days interval if the infestation continues.

(ii) *Mites:* Spray 0.05% Formothion or 0.03% phosphamidan (Dimecron) on the appearance of mites.

C. Smuts: (a) Vitavex at 2.5 gm/kg of seed may be used for effective control of loose smut of barley (only recommended for seed production);

(b) For controlling covered smut of barley, seeds should be treated with organo mercurials, before sowing (Agrosan G.N. at 2 gm/kg of seed).

ROLE OF RESEARCH IN REVOLUTIONISING DAIRY INDUSTRY

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INDIA has made rapid advances during the post-independence period in the field of dairying through research activities which have generally helped to change the structure of the dairy industry in India. Over 100 market milk plants for the organised collection, processing and distribution of milk and a number of milk products factories have been set all over the country. Along with these developments, attempts have been made to increase milk production in the country and to rationalise the methods of milk production and utilisation so as to meet the nutritional needs of the population and also ensure the economic development of the country. These developments have, in turn, raised a number of challenging problems connected with the breeding and feeding of cattle for milk production, adoption of modern technological processes in the handling and treatment of milk and manufacture of milk products under tropical conditions prevailing in the country. Several of these problems have been tackled and valuable data collected in the course of the research work carried out in the past 25 years at the National Institutes under the Indian Council of Agricultural Research, agricultural universities and other traditional colleges. Among the significant developments that have taken place recently, mention can be made of the formulation of the all-India coordinated research projects to solve the problems of national importance to the country.

India possesses a large livestock population which includes about 226.8 million cattle and buffaloes. Cattle rearing in the country has been carried out under adverse climatic and environmental conditions and is centered around small cultivators whose main occupation is crop production. The main handicaps in the promotion and growth of dairy industry in India are not only the adverse climatic conditions, poor grazing, inadequate marketing facilities, but also the fundamental ones as the poor genetic potential of a large majority of the livestock and the acute shortage of feeds and fodders. The main emphasis of the research in the field of dairying has been to solve these critical problems.

Production and Conservation of Fodder

Fodder production exclusively for cattle feed was not adopted by the farmers a few years ago in most parts of the country. However, in the context of breeding cattle for higher milk production, a need was felt for the promotion and cultivation of special types of fodder crops and fodder grasses. Due to intensive research, propaganda and demonstrations conducted, many farmers are now regularly growing exotic fodder grasses, viz. Giant Hybrid Napier, Guinea grass, Rhodes grass and Paragrass. Lucerne, berseem, several varieties of cowpea and guar are some of the leguminous fodder crops that are also being grown and have become popular with the farmers. The National Seeds Corporation is particularly involved in the production of improved fodder seeds in large quantities to ensure steady quality seed supply to the farmers. The State Governments are also running a few fodder seed production centres to meet part of their seed requirements.

Another important development in the field of dairy husbandry has been the production of good quality silage from paddy straw by ensiling with berseem. Utilisation of good quality roughages without recourse to the concentrates in the rations of cattle and substitution of costly protein feeds with urea in the concentrate mixture have been responsible to bring down the cost of feeding the cattle resulting in the lowering of the cost of milk production.

Cross Breeding

The average milk production of the cattle is extremely poor as compared to that of the exotic animals in foreign countries. This is a result of unplanned breeding over large areas of the country and the emphasis on draught quality for supply of motive power of agricultural operations and rural transport. Our past experience has shown that increases achieved from Plan to Plan as a result of developmental programmes in the field of Animal Husbandry have barely kept pace with the simultaneous increase in human population with the result that per capita availability of milk has remained static at the level of 135 gm per day over the past two decades. There is a wide gap in the production of milk and the actual requirements of the country for milk. This is a challenge to our Animal Husbandry scientists and producers. The experiments carried out on a limited scale at the Research Institutes and the Military Dairy Farms have indicated that cross-breeding is one of the methods which could be adopted to increase milk productivity of our cattle. From the experiences gained, the scientists and the policy makers have unanimously agreed to accept cross-breeding as a national policy. The ultimate purpose of breeding programme is to introduce into Indian cattle germplasm for high milk production, earlier sexual maturity and regular breeding. The observations from a cross-breeding project at Harrighatta have definitely indicated that the milk production of the cross-breds is more than double than those of the contemporary indigenous cows. The preliminary reports from a number of centres have indicated that cows with 50 to 62.5% exotic inheritance are more efficient in production and reproduction than those beyond this range. The experiments on cross-breeding carried out on a limited scale at different Research Institutes have shown encouraging results in improving the productivity of our cattle and indirectly bringing down the cost of milk production. Considering the importance of the cross-breeding, a gigantic all India coordinated research project on cross-breeding of cows has been undertaken by the Indian Council of Agricultural Research at different centres in the country for development of milch breed by cross-breeding of indigenous cattle with exotic breeds of Jersey, Holstein, Friesian and Brown Swiss. The results of researches up-to-date have paved the way for increasing milk production in the country and it is expected that in the near future India will be able to produce sufficient milk to meet the demands of its population.

Chemical and Bacteriological Studies of Milk

The total annual production of milk is estimated to be about 21 million tonnes, of which 39% is consumed as fluid milk and the rest is utilised for the preparation of various milk products like dahi, butter, *ghee*, *khoa*, ice-cream, etc. Investigations in the chemistry and bacteriology of milk have been directed primarily towards (i) building up basic data regarding the variation in the chemical and bacteriological quality of milk for formulating standards of quality, (ii) getting insight into physico-chemical properties of buffalo milk with a view to modifying the procedures for the utilisation of buffalo milk in the manufacture of milk products and (iii) preparation of various import substitutes and other material required by the industry.

The shortage of milk and *ghee* in the country has raised a critical problem of adulteration. The scientists have been able to solve this problem by developing suitable methods for detecting adulteration of milk with water and also adulteration of milk with diluted buffalo milk by a test called 'Hansa Test'. This test has been successfully used in various States in the country. The adulteration of *ghee* with vegetable and animal body fats had been a very serious problem for a long time. We now have a simple method to detect the adulteration of the *ghee* by use of paper and thin layer chromatography and the detection of animal body fats by use of simple Opacity Test.

The application of various chemical and bacteriological tests for examination of the quality of milk and milk products and the interpretation of the data under local conditions have been the subject of considerable research. All the various tests used in the laboratories were based on the work carried out in the foreign countries. Systematic work carried out in the country has enabled us now to adopt the methods developed in our country for the examination of the quality of milk. In this connection, we can cite an example of an accelerated resazurine test developed in our country with the help of which we are now able to rapidly screen and eliminate poor quality milk supplied on the receiving platforms in the dairies.

From the detailed studies on the growth characteristics and the biochemical activities of different strains of lactic acid bacteria isolated from *dahi* and other fermented products, single strain of mixed starter cultures suitable for use in the manufacture of *dahi*, yoghurt, butter, cheese and other products have been developed. Optimum conditions for the freeze-drying of culture in the ampoules and vials have also been standardised and the lyophilised cultures have been found to retain their viability and activity for more than one year at atmospheric storage temperature.

Technology of Milk and Milk Products

Research work in dairy technology has been mainly concerned with methods of chilling and transport of milk, techniques for the production of *dahi*, milk concentrates and cheese from buffalo milk and also development of techniques for better utilisation of sub-standard milk. In India, many difficulties arise in the handling of fresh milk on account of adverse climatic conditions. Systematic studies carried out on the comparative efficiency of different methods of cooling at the National Dairy Research Institute have led to the development of milk cooler working on the principal of absorption refrigeration. This chilling unit will be very useful in preserving milk in rural areas.

In view of the nutritional and economic importance of *dahi* in the country, considerable research has been carried out at the National Dairy Research Institute, Karnal, to develop suitable starter cultures for the preparation of sweet and highly flavoured dahi and yoghurt. Methods for the preparation of short-set and long-set *dahi* are now standardised and it is possible to obtain a product of very good keeping quality. A special *dahi* making outfit having arrangement for the incubation of milk after the addition of starter culture and for rapid cooling of dahi to stop fermentation process, has been designed. This process can be adopted for large scale production of dahi in the dairy plants. A process for incorporating carbondioxide in the fermented product to inhibit the growth of spoilage types has been worked out. It has now been possible to keep the carbonated *dahi* or yoghurt in a good condition for more than a week without any tendency to whey off or show other defects. This process is being adopted at the Bangalore Dairy and the Baroda Dairy for large scale production and distribution of *dahi* in suitable containers to the consumers.

Cheese, a popular food product in the western countries, is now finding a prominent place in the Indian dietary. In the past buffalo milk was not considered suitable for cheese making. As a result of systematic investigations on the use of buffalo milk for cheddar type cheeses, it has now become possible to produce and market cheddar cheese and processed cheese which are comparable to the quality of the imported cheeses. The requirement of prolonged curing period for cheese from buffalo milk has further led to the investigations for development of quick curing varieties of cheese. One such variety developed at the National Dairy Research Institute is quick curing cheddar type cheese which requires only 6-8 weeks for maturing. Along with the work on the development of semi-hard cheeses, attention has been paid to the standardisation of techniques for the isolation of milk solids from skim milk and butter milk. This has helped in the production of soft cheese-like base suitable for subsequent conversion into sweet and spiced varieties of edible products.

In view of the fact that buffalo milk is the most suitable raw material for dairy products manufacture, considerable attention has been paid towards the development of technology for the production of condensed and dried milk. Problems of early gelation and discolouration in sweetened full-cream buffalo milk encountered by earlier workers have been satisfactorily solved. A number of problems encountered in the manufacture of spray-dried powder from buffalo milk were solved satisfactorily and the baby food project was implemented at the Amul Dairy with the technical co-operation and the know-how developed at the Central Food and Technological Research Institute, Mysore. This product compares favourably well with the imported baby foods and the total production in the country has been substantially increased to meet the requirements of the country.

Whey is a by-product in the manufacture of cheese, paneer or chhana and is a very important source of lactose, whey protein and soluble vitamins. This is normally thrown away for want of suitable techniques for its utilisation. The feasibility of manufacturing high grade lactose from cheese whey has now been successfully demonstrated. The whey is also being successfully utilised for the production of soft drink called "Whevit". This product has been manufactured on a pilot scale at Karnal and has found great popularity among the consumers. Another outlet for the utilisation of whey has been the production of alcoholic beverage containing 4 to 12 per cent of alcohol. The utilisation of whey for the production of whey drinks and lactose will go a long way in preserving the nutrients in improving the economy of the modern dairies.

Thanks to the research work carried out by the scientists that we have now better picture of the composition and structure of milk, particularly that of buffalo milk. This has not only enabled us to develop techniques suitable for the production of major milk products, but also utilise the by-products for better economic returns to the producers. It is worthwhile mentioning here that we have now the technical know-how for a number of dairy requisites, viz. butter colour, cheese colour, animal and bacterial rennet, phosphatase reagent, iodophor (detergent used in dairies), nisin, edible caseinate, etc. The techniques if properly exploited will help in promotion of the dairy industry, improvement of the economic status of the farmers and also save the foreign exchange required for procurement of these items. In summarising, it will be observed that significant achievements in the field of dairy research have been made during the last 25 years and have paved the way for putting the dairy industry on a sound footing.

Future Approach

Complete success in the field of dairying is possible only when milk, which is an essential item of food, is made available in adequate quantities to the different sections of the population including children, expectant and nursing mothers and invalids. To reach this target, which is an increase of about 100 per cent over the present production, a comprehensive integrated programme is required to improve the productive efficiency in cattle and buffaloes through improved breeding, feeding and management practices. The recent launching of six all India coordinated research projects in the breeding of cattle and buffaloes and on the technology of milk and milk products by the Indian Council of Agricultural Research is the beginning of a new era in dairy research.

Milk trade is at present generally disorganised and only about 3 per cent of the total milk production is in the hands of the organised sector of the industry. The effectiveness of the process of diverting the milk from unorganised sector will depend not only on increased milk production, but also on the effectiveness of the link between dairy plants and the milk producers in their milk shed areas. This link can be established more efficiently by setting up of small dairies in towns with a population ranging from 25,000 upwards. The problem of starting small dairies is closely linked up with the procurement of surplus milk from villages which are cut off from the cities due to inadequate transportation facilities and milk collection agencies and it is expected that this will be solved through a project known as Operation Flood Programme launched by the Department of Agriculture through the funds made available from World Food Programme.

Apart from the development of dairy industry, a great deal of fundamental work in dairy research is needed to improve the quality of milk products like *dahi*, *khoa*, cheese, chhana, ghee, butter, ice-cream, milk powder, etc. It is of upmost importance that there should be coordination between research institutions and the results of researches should percolate into actual operations through the channels of extension and management. The speedy implementation of the dairy projects in the coming decade will, it is hoped, substantially contribute to the development and progress of dairy industry and will help India occupy a leading position in the Dairy Map of the world.

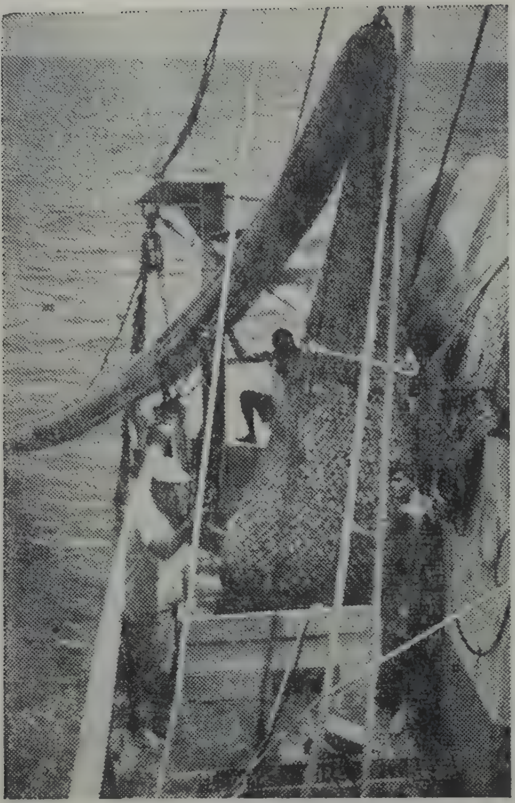

Fig. 1. A trawl ready to unload its catch

OCEAN HARVEST

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BEFORE 1947, fisheries research and development in India were considered the main responsibility of the then provinces and states. The Government of India had no direct interest in fisheries. The state departments of fisheries were mainly concerned in collecting revenue and very little effort was made to develop an understanding of the living marine resources. Most of the earlier studies were of a faunistic nature, and these were carried out by the Zoological Survey of India. Of the then existing maritime states, Madras and Bombay were the only states where some fundamental work related to regional fisheries was done. During the Second World War, the lack of good quality fish, especially for the British and American military personnel, led the Government of India to formulate a policy of research, development and conservation of fishery resources similar to those of agriculture, forestry and veterinary.

The Central Marine Fisheries Research Institute was started in February 1947, the year of Independence.

One of the important achievements in marine fisheries has been the development of a statistical system to assess the marine fish production of the country. Before the CMFRI was established, we had no reliable mechanism of estimating the fish production of the country. In 1947 the fish production was roughly estimated at 4 lakh tonnes. The assessment of fish production is made not only in terms of total quantity, but also in the species composition, age and size groups entering the fishery, seasonal abundance and the total effort involved in relation to landings, including catch per unit effort. Some relevant information of a general nature pertaining to fishery industry of India is as follows.

Fish production along west coast = 76% of the total
Fish production east coast = 24% of the total
Number of marine fishing villages = about 1,800
Number of fish landing centres = about 3,200
Total fishermen population = over 1 million
Number of active fishermen = about 250,000
Number of fishing craft = about 100,000
Number of mechanised boats = about 10,000
Total revenue to the country from marine fishery in 1971 = about Rs. 1200 million (120 crores)
Total foreign exchange earnings from fishery products 1971 = about Rs. 400 million = (40 crores)

During 1970 the marine fish production in the country for the first time crossed one million tonnes and was estimated at 1,085,607 tonnes, and in 1971 it was approximately 1.2 million tonnes. The following Table (on page 105) gives the state-wise marine fish production in tonnes during the last three years.

Fig. 5a gives the composition of important fisheries in the total catch. Fig. 5b indicates the contributions of maritime states in the sea harvest. The total landings for the country during the past 22 years have been shown in Fig. 6. From 1959 to 1964 the total yield was of a fluctuating nature, but during 1964 and 1965 the catches became somewhat

Fig. 2. Harvested fish on the deck of a fishing vessel

stable and recorded a sharp increase from 1966 onwards (Fig. 6).

The marine resources of the country can broadly be divided into two main groups: (1) pelagic and (2) demersal.

State	*Years*		
	1969	*1970*	*1971*
West Bengal & Orissa	22,879	31,403	27,255
Andhra Pradesh	77,526	74,459	83,289
Tamil Nadu	151,876	155,516	160,214
Pondicherry	10,637	10,624	10,453
Kerala	294,787	392,880	445,605
Mysore	75,793	116,936	103,978
Goa	27,559	20,736	21,000
Maharashtra	168,720	192,361	216,340
Gujarat	82,248	89,027	84,941
Andaman	412	500	569
Laccadives	1,193	1,165	1,200
Total	913,630	1,085,607	1,154,844

Pelagic Resources

Pelagic resources are those which are found within the water column both in the regions of the continental shelf and in the open ocean. These collectively constitute the largest harvest, about 63% of the total, and include sardines, mackerel, Bombay duck, tunas, billfishes, oceanic squids, etc. Of these, the two major fisheries, oil sardine and mackerel, form about 32% of the total annual catch.

Oil Sardine. The species which constitute the fishery is *Sardinella longiceps* and is known as *Chala* or *Mathi* in Malayalam and *Tarali* in Marathi. The region for maximum abundance of this species is from Ratnagiri in the north to Quilon in the south. It constitutes, nearly 24% of the total marine fish landings (average of recent years=2.5 lakh tonnes). Since ancient times this fishery is being exploited by the indigenous craft and gear. The gear employed is large boat seine operated within the 50 metre depth zone. The fishery on the west coast generally commences in August and continues till about April. In addition to the considerable importance of the oil sardine as food, its oil has several uses in jute, leather and soap industries. The fertilizer "guano" from this fish is used in coconut, coffee, tea and other plantations. Fig. 7 shows the landings of oil sardine for the past 22 years. From 1950 to 1963, the fishery has been of a fluctuating nature recording the worst setbacks in 1956 and 1963. It achieved a phenomenal revival from 1964 onwards.

For the first time in India attempts have been made to tag the oil sardine and release them into the sea for studying their growth, migration and mortality. In order to make this venture a success, wide publicity is being given through handbills and posters in different languages soliciting cooperation of the fishermen and the general public to return the tagged fish to any of the Units, Substations and Centres of the Central Marine Fisheries Research Institute.

Indian Mackerel. The mackerel fishery comprises a single species *Rastrelliger kanagurta* which is known

Fig. 3. Sorting of harvested fish on board a fishing vessel

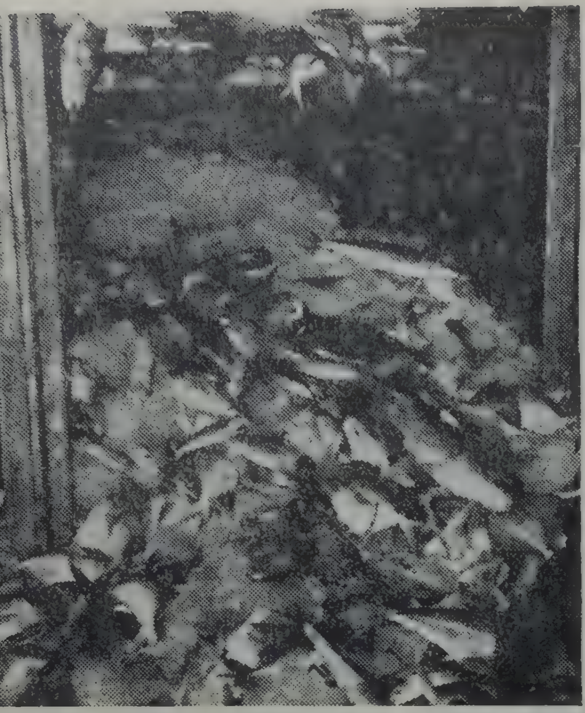


Fig . 4 Sorted fish kept in crushed ice in the hold of a fishing vessel

as *Aila* in Malayalam and *Bangara* in Marathi. This species is mostly caught along the west coast and contributes as much as 7% of the total marine fish catch. The main region for its fishery is from Ratnagiri to Cape Comorin, although the area where maximum fishery occurs is between Ratnagiri and Quilon. The fishery for mackerel is also on the east coast near Madras, Kakinada, Vishakhapatnam and in some areas off Orissa. The most common gear used for mackerel along the west coast is the shore seine called *Rampani*. It consists of 400-600 pieces of net made of hemp or cotton yarn, joined together and operated by 80 persons with the help of several boats. Total landings of mackerel from 1950 to 1971 have been shown in Fig. 8. The mackerel fishery has been of a highly fluctuating nature. In 1971 it reached an all time record of approximately 1.9 lakh tonnes. The fishing season lasts from August to March and the heaviest landings occur along the Mysore-Kerala coast. The tagging programme for this species also has been initiated on the west coast at the various Sub-stations and Units of the Central Marine Fisheries Research Institute in order

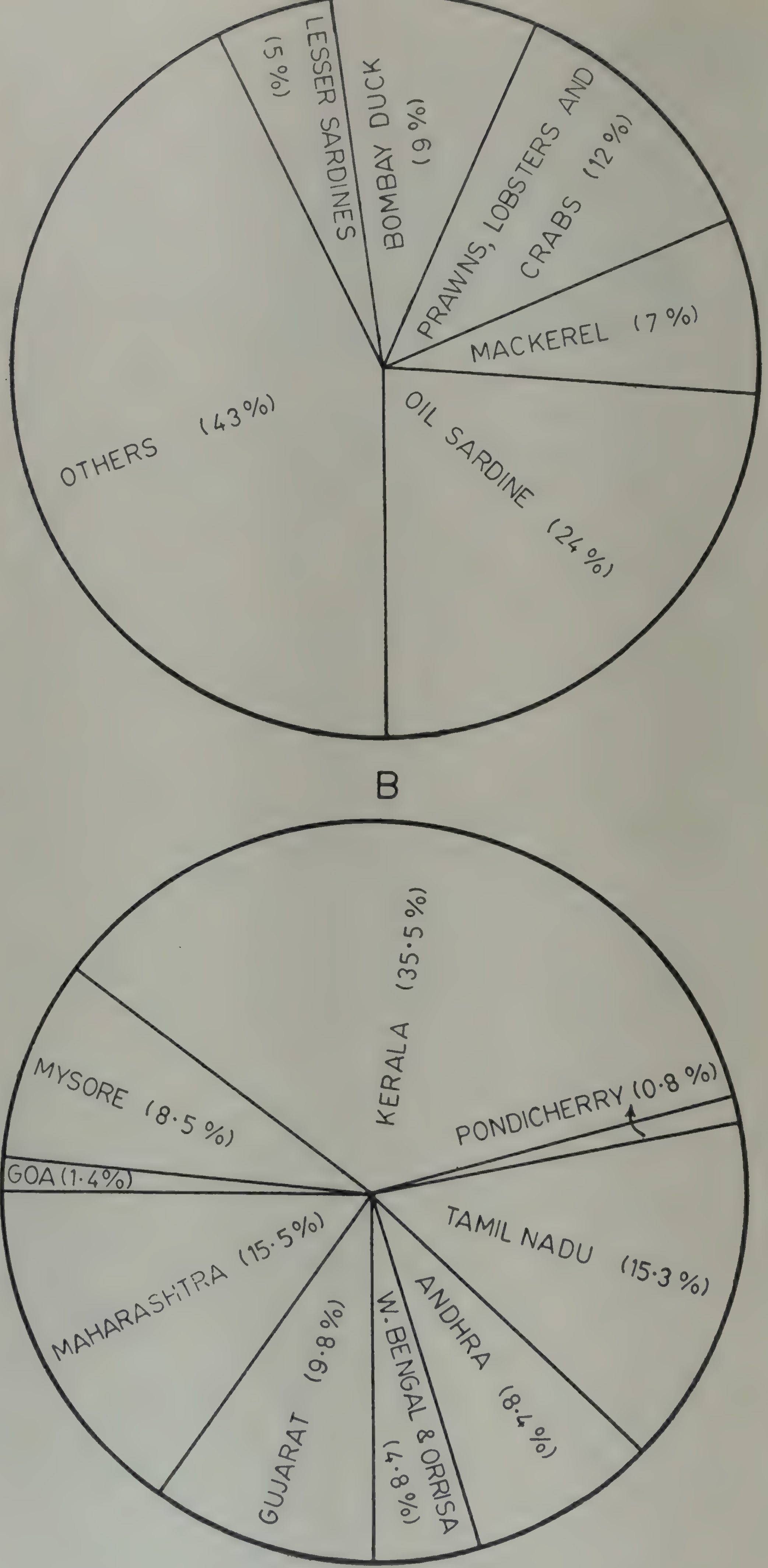


Fig. 5 A Percentage composition of six major fisheries of India
B Percentage contribution of nine maritime states of India in the total fish landings. The value in both the figures are the averages of ten years.

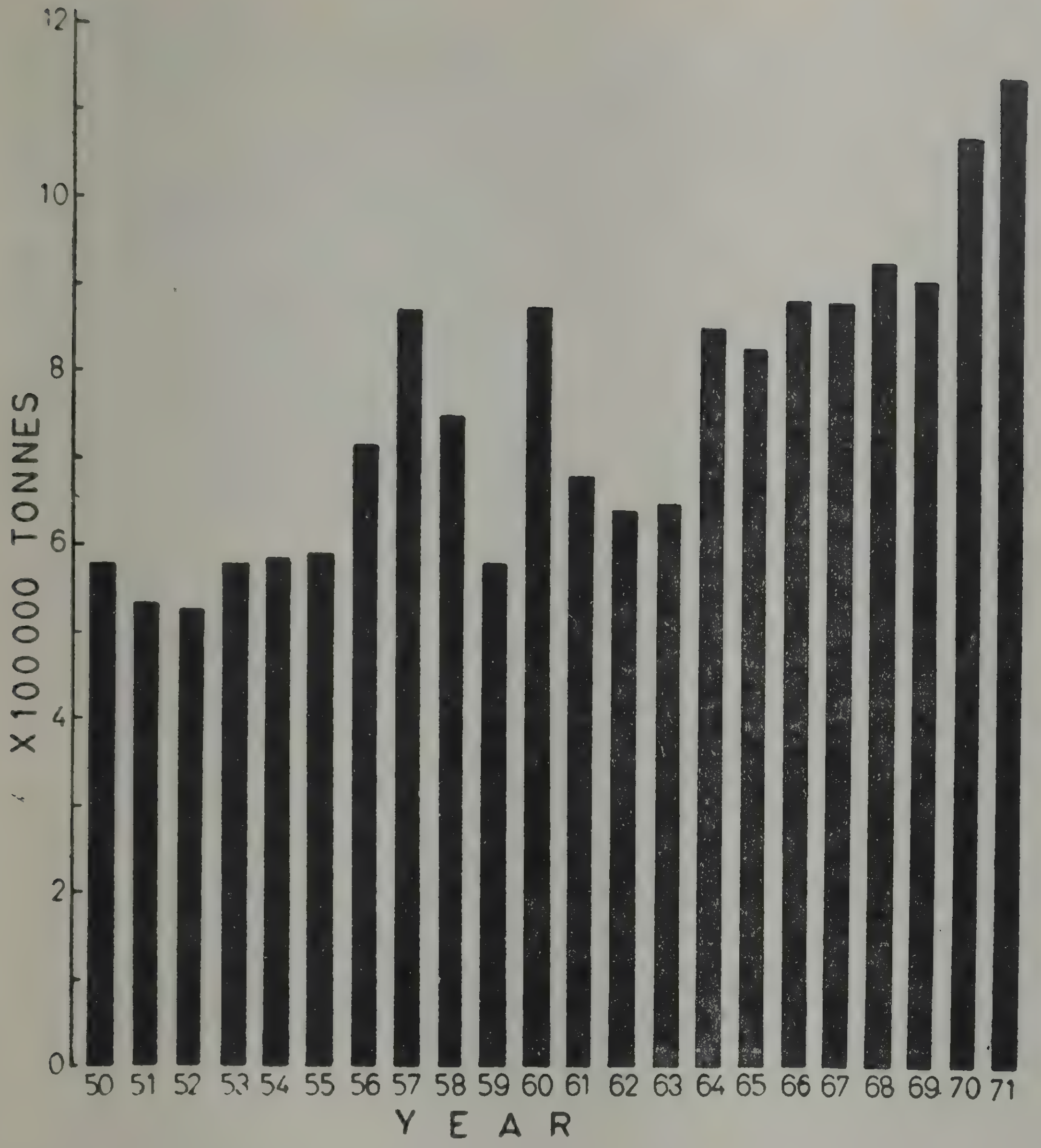


Fig. 6 Total landings of marine fish in India during the past 22 years. (1950 to 1971)

to study its rate of growth, migration and mortality.

Bombay-Duck. The Bombay-duck fishery is supported by a single species, *Harpodon nehereus,* popularly known as *Bombil* in Maharashtra. The main regions for its fishery are Gujarat and Maharashtra coasts on the west and along the Andhra and Orissa coasts on the east. On the west coast, the fishing is mainly done by the bag nets locally known as "Dol", but on the east coast it is caught by the boat seine. The fishing season lasts from September to April. The total landings are of the order of 1 lakh tonnes which constitute about 9% of the total marine fish landings. The landings of this fish for a period of 22 years have been shown in Fig. 9. The fish is consumed both in fresh and dried state.

Tunas. At present there is no organised fishery for tunas except for the traditional pole and line fishery for the skipjack in Minicoy and in some of the islands of Laccadives (Kavarathi and Agathi). During the last 5 years small mechanised boats have been constructed for pole and line fishing in the Laccadives and at present about 30 such boats are in operation in addition to the indigenous tuna fishing boats at Minicoy.

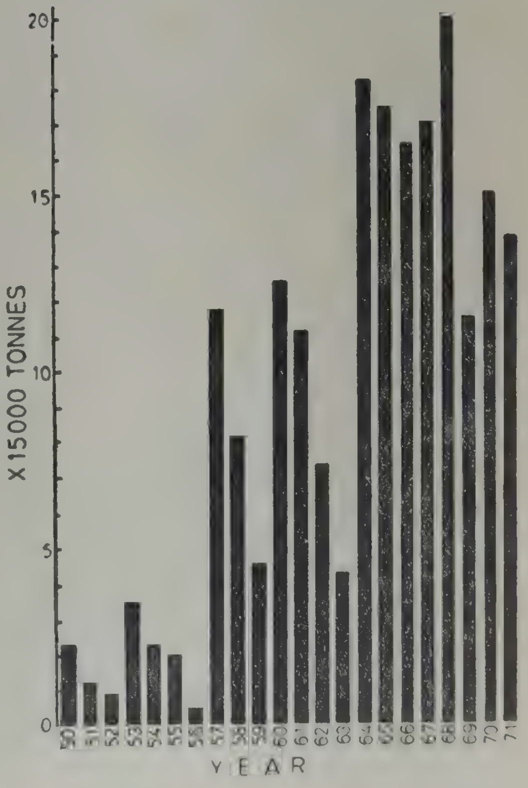
The Central Marine Fisheries Research Institute has already drawn attention to the need for developing tuna fishery in the country, particularly as an additional source for earning foreign exchange. The extensive fishing operations carried out by the Japanese in the Indian Ocean using long line have proved that this method gives very fruitful results. The same method of fishing has been adopted by several other countries such as Taiwan, South Korea and Singapore. At present the annual yield of tuna from the Indian Ocean is about 175 thousand tonnes. The bulk of this is landed by the Japanese tuna long line vessels. The total tuna catch by the Indian vessels is only about 5 thousand tonnes per year.

Demersal Resources

Demersal resources are those which are found at or near the bottom of the sea. The exploitation of these resources using power driven vessels and highly mechanised gears such as trawl has started only within the last two decades. Different organisations at present are engaged in large scale exploratory and commercial fishing operations from different bases. The important species harvested are: Dara *(Zolydactylus indicus)*; Koth *(Otolithoides brunneus)*; Ghol *(Pseudosciaena diacanthus)*; Wam (eels); Karkara *(Pomadasys hasta)*; Shende *(Polynemus heptadactylus)*; carangids, silver bellies and prawns.

Prawns. One of the most important demersal resources harvested

Fig. 7. Landings of oil sardines during the past 22 years (1950 to 1971)



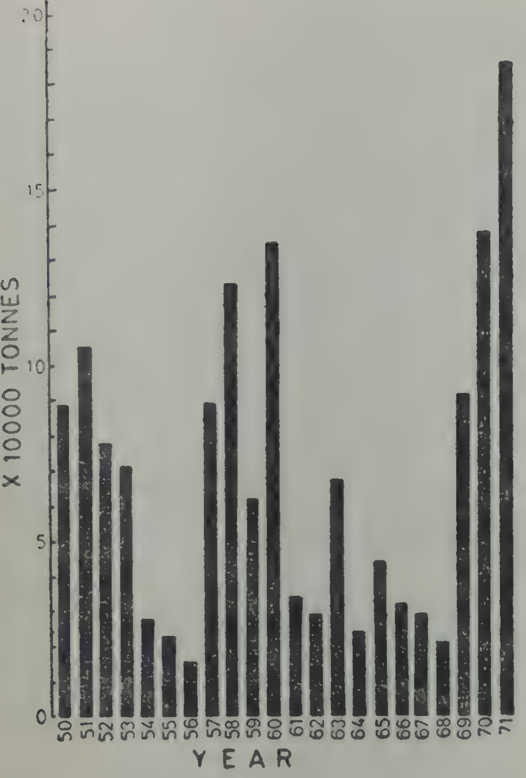
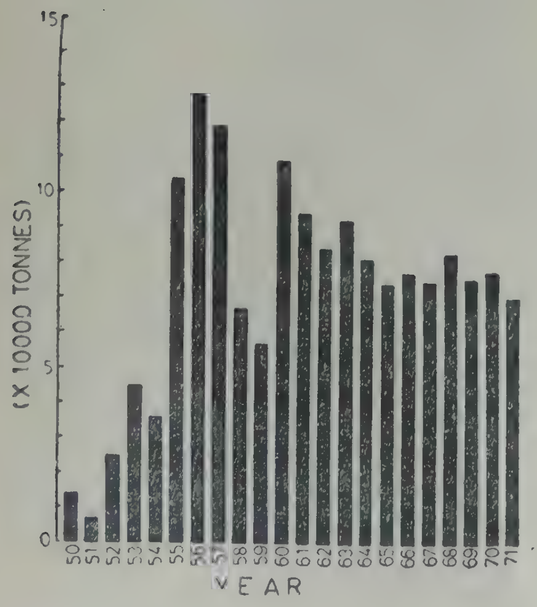


Fig.8. Landings of mackerel in India during the past 22 years

in India is prawn. The expansion of export trade of frozen and canned prawns has given a very great impetus to mechanised fishing for prawns. The average annual marine prawn landings in the country is more than 1 lakh tonnes which is about 12% (including lobsters) of the total annual fish catch. Marine prawns belong to two major groups viz., penaeid and non-penaeid. Penaeid prawns are relatively large sized and form an important commodity for export to countries such as the United States and Japan (see Fig. 10). The other important item for export is the deep-sea lobster, *Puerulus sewelli* (see Fig. 11). The fishing season generally starts from October and ends in May. In recent years the processing of prawns by freezing and canning has improved considerably and most of the Indian seafood products have strict quality control and are well accepted in the world market. Fig. 12 gives the total landings of prawns from 1958 to 1971. Unlike the fisheries of oil sardine and mackerel, the prawn fishery has been of a stable nature and from 1965 onwards it recorded a steady rise. The total prawn production in the world is about 7 lakh tonnes, of which India's contribution is about 1.4 lakh tonnes. This places India as the largest prawn producing country in the world. Fig. 13 gives the export of total marine products (prawns, lobsters, etc.) to different countries and their values in Indian rupees. The B part of Fig. 13 gives the export of prawns alone. From 1962 onwards our export has been constantly on the increase, and the value of the Indian seafood in the world market has also been rising steadily.

Fig. 9. Landings of Bombay duck during the past 22 years



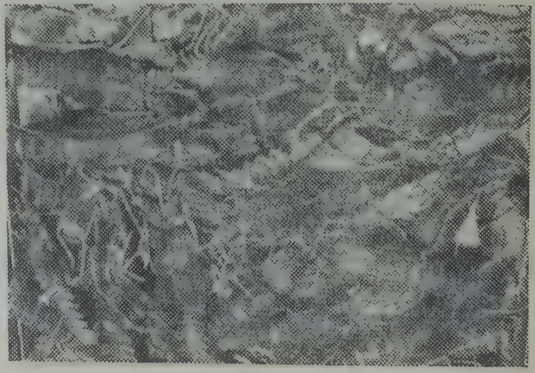
Molluscs. Molluscan species such as clams, oysters, mussels and squids are utilized as food in different-parts of India. A survey of resources, methods of their exploitation and the possibilities of their culture by employing suitable techniques are being undertaken at present in great detail. Extensive underwater surveys of pearl and chank beds off Tuticorin have been made by the scientific staff of the Central Marine Fisheries Research Institute using aqualung and regular charting of molluscan resources is being carried out. The fishing season varies from region to region. Fishing by skin-diving is the method practised along the south-east coast of India. The introduction of modern diving equipment has given a great impetus to our knowledge of the molluscan resources (see Fig. 14).

Fig.10 . Harvested prawns from the sea form an important item of export

Harvest of Vegetable Food From Sea

In many countries, marine algae, which are popularly known as "seaweeds", are utilized as human food (see Fig. 15). In Japan, some twenty different kinds of algae are being consumed. In Philippines and Hawaii also several species of algae are regularly eaten. There are several species of seaweeds which contain gelatin. This product is used for the preparation of jelly and jam. Dried seaweeds (known as China grass) are regularly used in domestic cookery for making sauces, soups, puddings, etc. The active ingredient in such seaweeds, which thickens the fluid, is agar. Algin or sodium alginate, which is a product of the algae, is also used as a gelling substance. In addition to these products, some of the seaweeds

Fig.11. Deep-sea lobster is a luxury food item and is largely exported



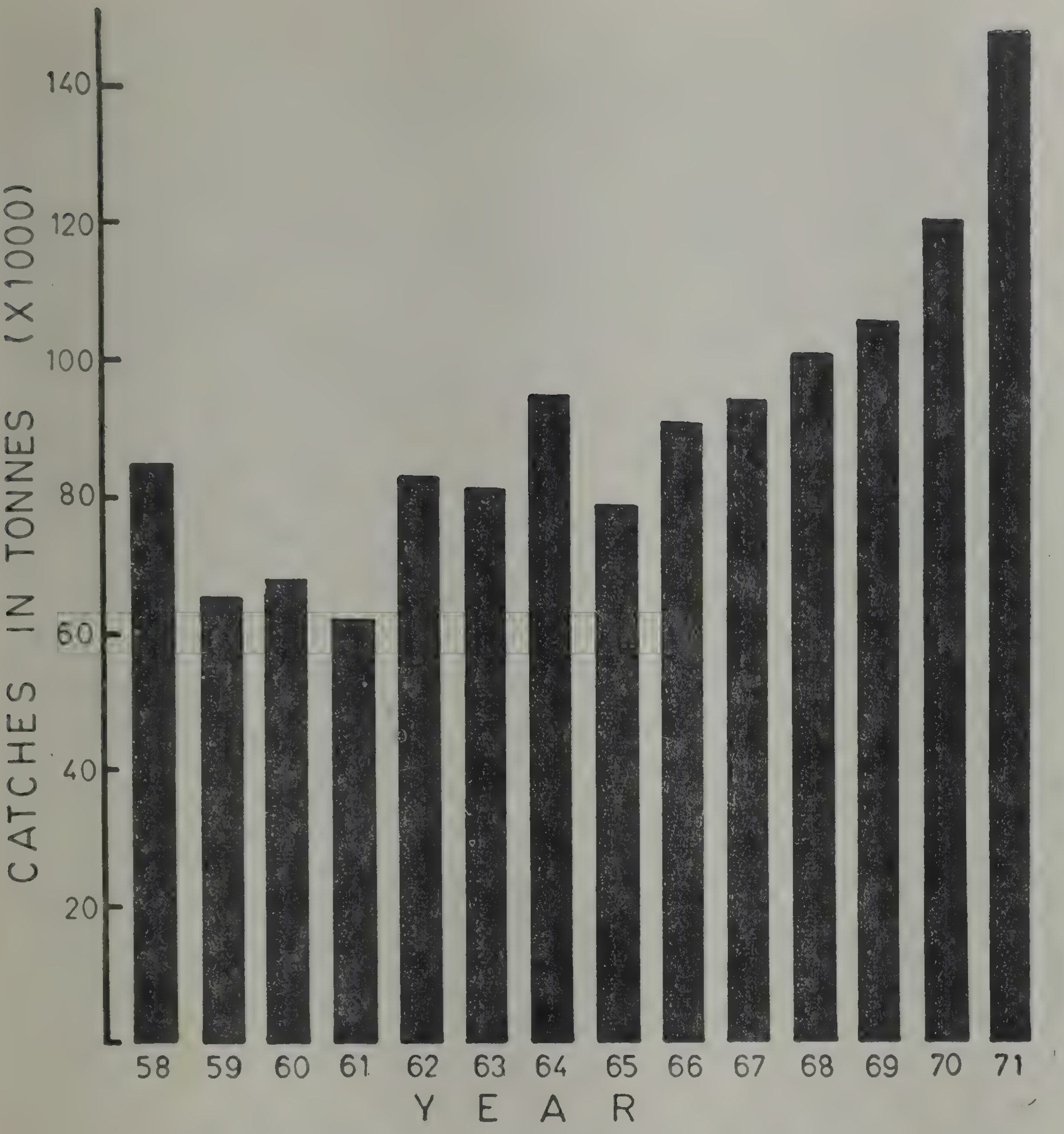


Fig. 12. Landings of Prawns during the last 14 years (1958 to 1971)

serve as a source of mineral such as iodine, manganese and iron. Several of these are being cultivated on ropes in sheltered areas of the sea. A few years ago India used to export seaweeds and the products from seaweeds such as agar and alginates used to be imported. Nowadays, the country has become almost self-sufficient in the seaweed products. Several factories are producing agar, gelatin and alginates and the demand of seaweeds is becoming greater every day. The seaweeds are no longer going out of the country.

Besides the larger algae, a tiny, invisible, unicellular alga, called *Chlorella,* has also been used as human food. This organism is so small that about 40 million cells can live in a tumbler full of water. It has an incredibly fast growth rate, and has the capacity to grow in any type of water. It has a fantastic yield of about 40 tonnes a year in an acre of water. By fertilizing the water with nutrient salts such as nitrate and phosphate, it can easily be cultured on a large scale.

Sea Farming

Freshwater fish farming has been in practice, in many parts of India, since ancient times. Ponds and lakes are easily manageable, as compared to estuaries and bays. It is, therefore, not surprising that true animal husbandry with sea animals has hardly been attempted until recently, and from the world-wide interest that the sea-farming has received in recent years, it appears that very soon the sea will be cultivated on a large scale. The animals which are now being cultured are shrimps, lobsters, oysters and clams. The yields of all these animals in culture are incredibly high. The regions which are well-suited for farming are the sheltered areas such as backwaters, estuaries, low-lying fields, swamps, lagoons, etc.

India has very large natural water resources, amounting to approximately 8 lakh hectares, suitable for aquaculture. In Kerala alone about 16,000 hectares of backwaters are available. How best these resources could be utilized, has been engaging the attention of scientific bodies. At the Central Marine Fisheries Research Institute, Cochin for instance, we have been conducting experiments on the rearing of young prawns for the last few years and have succeeded in culturing certain species of prawn in the laboratory. We are now going to make field trials, and very soon, the technical know-how will be available for farming prawns.

The Future

Today the world's seafood production is approximately 60 million tonnes, and from the Indian Ocean as a whole the catch is about 2.5 million tonnes; about half of it (1.2 million tonnes) is contributed by India. In the past the growth of the conventional fisheries in the world has been at the rate of about 10% every year. We hope that in future their growth will be much faster. In India the increase in fish production in recent years has been of the order of 15-20%. Nearly 60% of the population in developing countries, which comprises nearly two-thirds of the world's population, suffers from undernutrition, malnutrition or both. To meet the increasing demand for protein food, ocean harvest plays a major role and in future years, as the marine food production is expected to increase substantially, it is hoped that its cost to the consumer will possibly be reduced. Sea farming on a large scale will perhaps contribute a great

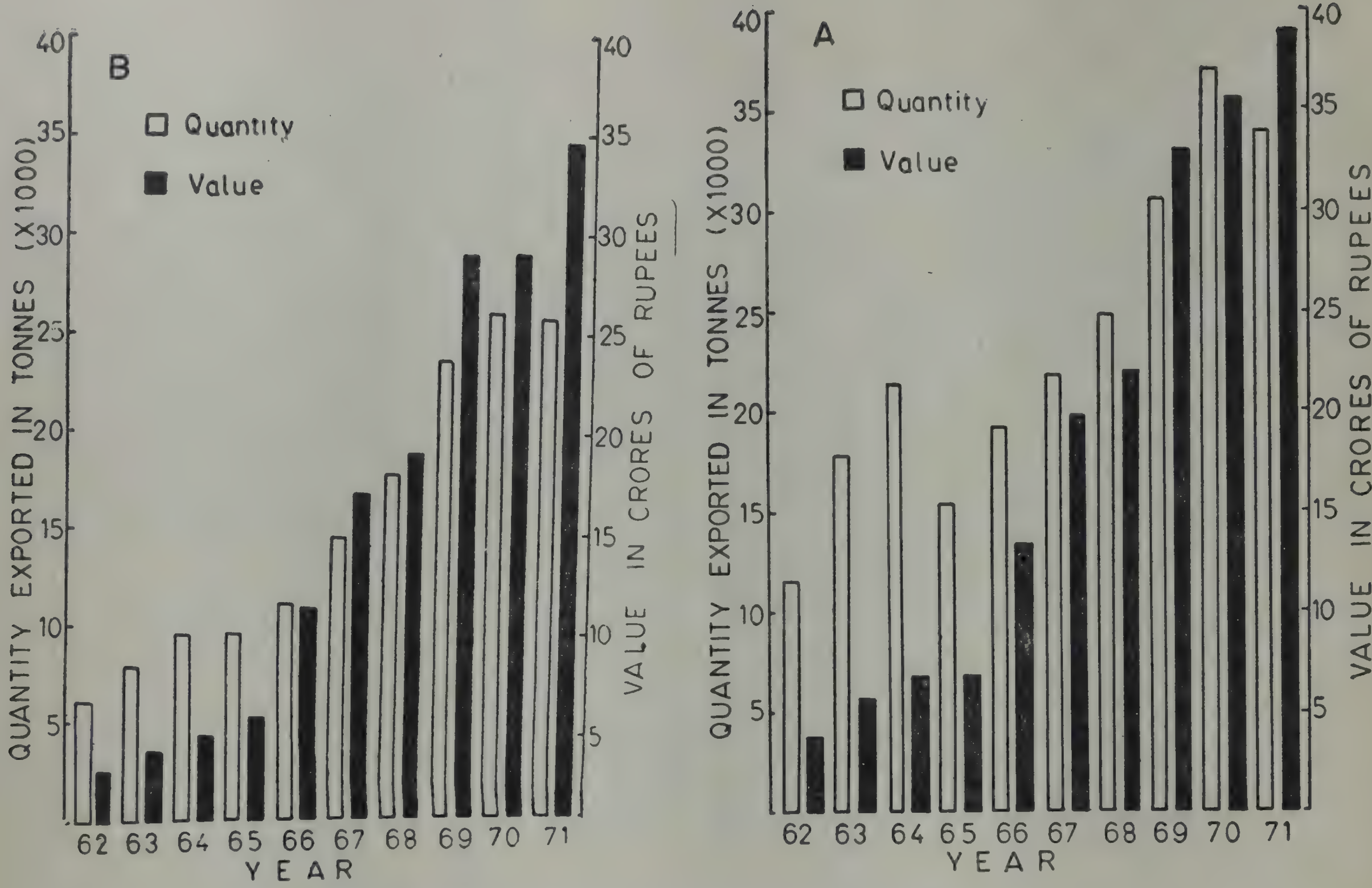


Fig. 13. Export figures of sea food from India from 1962 to 1971.
A. Total quantities of all sea food with value.
B. Total quantities of prawns and their value. Export of sea food started only in 1962.

deal to the lowering of the cost of seafoods.

A few years ago, the United Nation's technical agencies, such as the UNESCO and FAO had fostered far-reaching international co-operation for finding and exploiting marine resources. The International Indian Ocean Expedition (IIOE) was one of them, which gathered hundreds of scientists, from 25 nations, on a common platform and put 40 research vessels into sustained operation for 5 years. The IIOE thus became the first multi-national attempt to explore the sea—a unique example of international co-operation in science. India had its own programme during the IIOE. The programme started in 1962 and

Fig. 14. A scientist from CMFRI doing SCUBA diving. Underwater survey of sea beds forms a part of the Institute's programme.

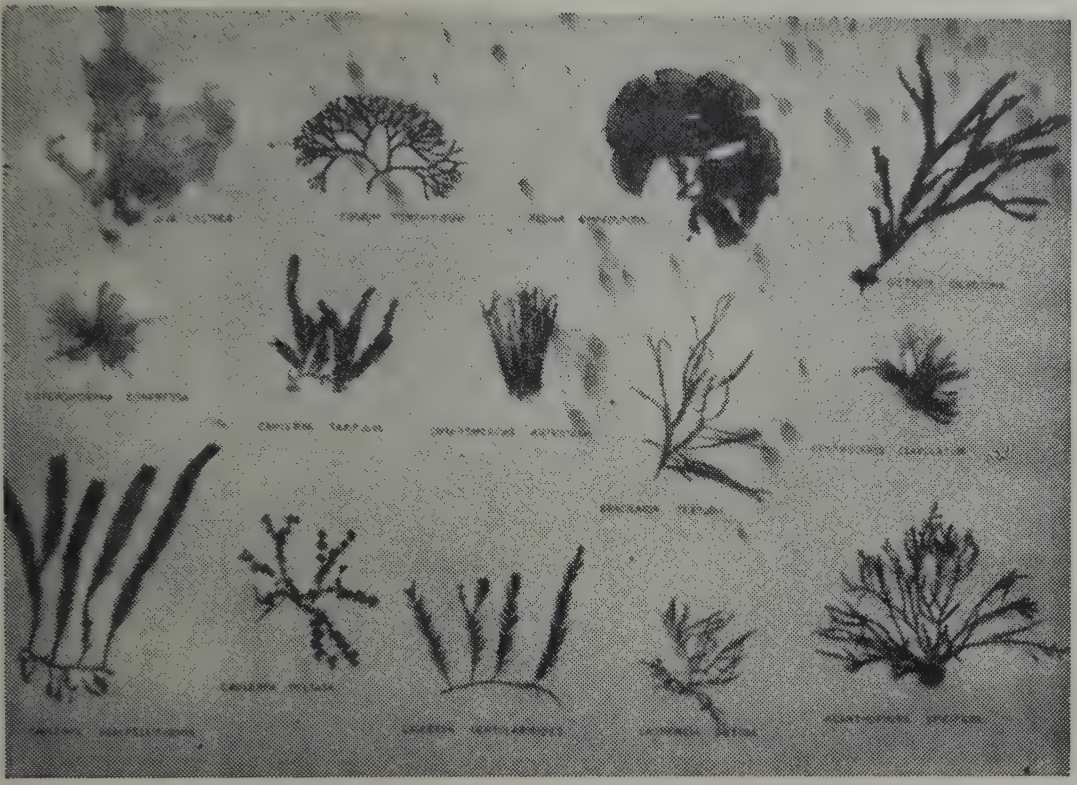


Fig. 15. Different varieties of edible seaweeds along the shores of India. A survey of seaweed resources for food and industrial purposes is being undertaken by the Institute

ended in 1965. The active participation of India in the expedition was of great value to the oceanographic and fishery researches in the country. India played host to scientists from many nations and many participating foreign ships provided facilities of shipboard and research to many Indian scientists.

We hope that in future years the ocean harvest, aided and enlarged by modern technological advances, will not only increase substantially, giving a boost to our export many times greater, but would also be able to provide this high quality protein food to the neighbouring undernourished nations also. India, being the leading nation among the countries bordering the Indian Ocean, must continue to pay as much attention towards the sea harvest, as it rightly deserves.

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FISHTECH Nos. V II, IV and VIII. Four of the fishing vessels designed and built by the CIFT, Cochin and used as investigational vessels

TECHNOLOGICAL RESEARCH IN INDIA'S FISHERIES DEVELOPMENT

V. K. PILLAI
Director, Central Institute of Fisheries Technology, Cochin

INDIA today occupies the seventh position among the leading fish producing countries of the world. Marine fish production in the country increased to 1·154 million tonnes in 1971 from hardly half million tonnes in the early '50s and it is reasonable to assume that the target of an annual production of 1·345 million tonnes, fixed for the end of the Fourth Plan period will be accomplished. One of the most important factors that has contributed towards increased production is undoubtedly mechanisation of the fishing operations through introduction of mechanised fishing vessels of new designs and adoption of new fishing gear and methods. Attempts of the Central Institute of Fisheries Technology (CIFT) to this effect ever since its inception resulted in evolving designs of more than a dozen fishing vessels in the size range of 7·6—15·24 m for inshore and offshore fishing operations and it is significant that about 50% of the mechanised vessels operating in different parts of the country are built to these designs.

Commercial Fishing

Development of efficient trawl net designs for operation from various sizes of boats paved the way for introduction of this commercial method of fishing in selected regions in the initial stages and its widespread adoption in subsequent years.

Commercial trawling needed efficient gear handling equipment to make the operations easy and economical. Designs of trawl winches, gallows, gurdy, etc. and ancillary equipment like power-take-off clutch and jockey pulley developed by the Institute functioned complementary to the various types of boats and nets. Search for cheap but efficient construction materials for wooden fishing vessels so as to check the increasing cost of such boats resulted in recommending materials capable of bringing down the cost of construction by about 35% when compared to the cost of boat constructed out of conventionally used materials. Preservation techniques evolved for boats and nets served to prolong their service life for economic operation. Of particular mention is the technique of using aluminium alloy for sheathing underwater portion of wooden boat hulls in place of the conventionally used copper sheets as a measure of protection against marine deterioration. It is estimated that by replacing imported copper with indigenously available aluminium alloy sheets, an average annual saving of Rs 1·25 crores in foreign exchange is possible in the case of the boats now operating and which require renewal of sheathing and the boats that would be introduced as per the Fourth Plan target. Search for cheaper fishing boats is being continued by experimenting new materials like ferro-cement and marine quality aluminium for the hull and other structural parts.

Quality standards worked out for fishing net twines of different types enabled the manufacturers in producing quality products and the users in the selection of suitable

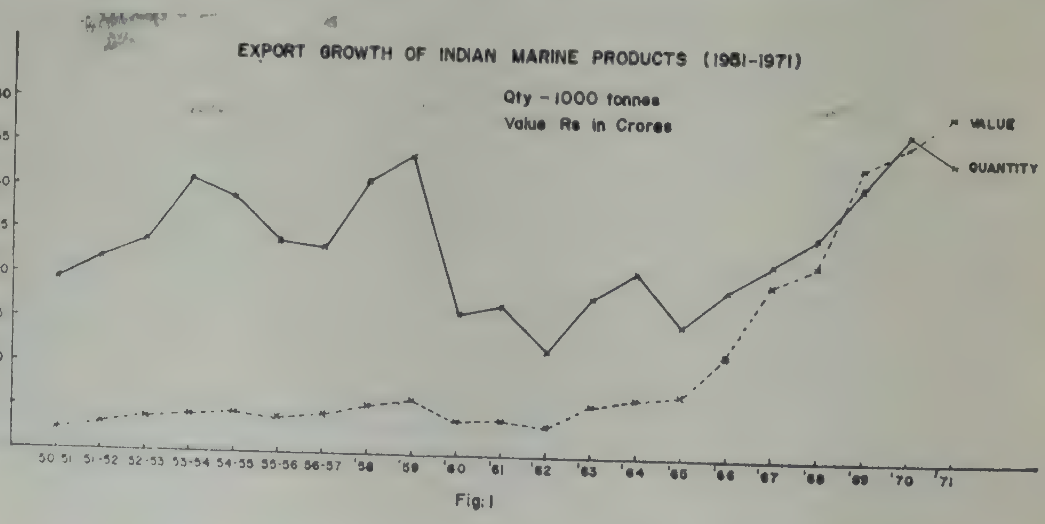


Fig: I

types. Based on the standards evolved, national standards were issued in respect of the important types of fish net twines. There has been rapid progress in replacement of natural twines like those of cotton by synthetic materials like nylon and low and high density polythylene for better efficiency and economic usage. New fish net twines being introduced include those of polypropylene and high density polythylene (HDPE) tape. Recent assessment has shown that HDPE tape twisted twine is likely to be the cheapest of the synthetic fish net twines so far introduced in the country and a rough estimate shows saving of about Rs 2 per kg when compared to polyethylene twines and Rs 23 per kg when compared to nylon twines of similar specifications.

Simultaneous with the attempt towards improvement of the trawl net designs efforts were made to evolve new types of gear and methods for diversified fisheries. Newer concepts in trawl net designs evolved at the different regional centres of the Institute both in the east and west coasts are slowly but steadily being adopted by fishermen in the respective area for more efficient fishing —as for example the six seam trawls in the Gujarat coast and the long wing trawl in the Andhra Coast. Development of the bulged belly type trawl deserves special mention in view of its proven efficiency in bringing 30% more catch on an average when compared to the catch of a conventional type of trawl of similar size.

Field trials on electrical trawling have also shown efficiency of the method in bringing more catch. Troll line operation from small boats has been seen to be a cheap method of fishing for Seer, Barracuda, etc., especially in the event of a failure in prawn fishery. Lining for other types of quality fishes like Perches is also being introduced from small and medium boats.

Technological research has also proved useful in the manufacture of marine engines for fishing boats. Assessment of the power requirement of different sizes of vessels for trawling operations enabled to recommend the correct horse power of engines for these vessels. Tests and trials of indigenously manufactured engines and suggestions given for rectification of defects and improving performance enabled the manufacturers in producing engines of better quality. Suitable drawings evolved for installation of the specific types of engines in boats served to overcome the technical problems encountered in the initial stages. Whereas the mechanisation programme in early stages depended on imported engines, marine engines for vessels up to the size group of 18 m length are now manufactured in the country.

Efforts made towards increasing fish production from the inland resources cannot also be overlooked. Typical reservoirs in some parts of the country have been surveyed and efficient gear evolved for exploitation of the natural fauna. Connected problems like weeding of inland water spreads also received attention. Weeding equipment has been evolved for removal of floating as well as submerged weeds from water areas up to 15 hectares.

Development in the Fish Processing Sector

More spectacular is the transformation of the country's fish processing industry in the post-independence era. India now ranks as one of the major fish processing and exporting countries in the world, particularly with regard to shrimp products. The level of exports increased from 19,651 tonnes in 1951 to 34032 tonnes in 1971 in terms of quantity and from Rs 24.56 million to Rs 391.72 million in terms of value during the same period.

In this rapid stride the industry was no doubt ably supported by technological research in the various disciplines involved. Whereas, in the initial stages the industry had to depend on borrowed technical know-how from importing countries today it can secure all the guidance and assistance from the CIFT, which has built up a strong Processing Technological Research Division. India's processed shrimp products today occupy a position second to none in countries like the USA, Japan, Australia, the UK. and some European countries.

Frozen prawns (top right) frozen lobster tails (bottom right) and frozen froglegs (left)

Quick frozen
LOBSTER

The Institute's Processing Division has since its inception in 1958, not only tried to keep ahead of the needs of the industry but also helped it from time to time to surmount technological problems that stood in the way of progress and development. The revival of the country's exports of cooked frozen prawn to Australia and that of frozen froglegs to France in 1967 and 1968 respectively are only two of the many instances where the Institute directly played its part. Practically new techniques were evolved in the quickest possible time for processing of both cooked frozen shrimp and frozen froglegs which could meet the quality requirements of the importing countries.

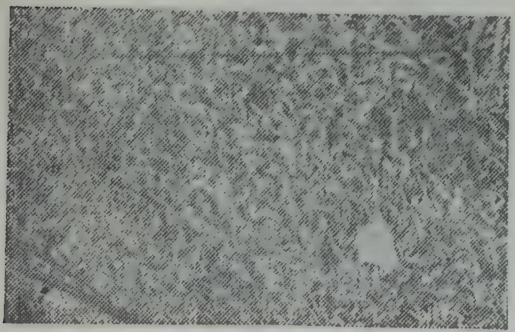
The main emphasis is in technological research work of the Institute has been :—

1. to avoid wastage during preprocess preparation and subsequent processing;
2. to evolve improvements so as to maintain the best quality capable of meeting the most stringent specifications in importing countries,
3. to work out methods for diversification of fishery products; and
4. to work out methods of commercial utilization of byproducts and wastes.

C.F.T.R.I.

Minimising Wastage. The Institute's efforts have helped to effect significant reduction in the levels of wastage occurring at various stages of preservation and processing of almost all commercially important varieties of fish and shell fish in the country. Standard procedures aimed at maximum efficiency and least wastage for preprocess preservation and further processing have been worked out for prawns like *Penaeus indicus, Metapenaeus affinis, Metapenaeus dobsoni*, etc., and fishes like Mackerel, Sardine, Pomfret, Bombay duck, etc. along with directives and guidelines for proper icing. In the case of shrimp which forms the major export commodity, wastage has been reduced from around 30% to less than 10 by adoption of process control measures recommended from time to time. Stricter enforcement of these measures holds out the possibility of reducing wastage still further.

A bumper catch from the bulged belly type trawl operated from the Institute's vessel



Equally significant is the wastage in the form of excess material added during freezing and packing of prawn. Investigations have shown that thaw drip loss can normally vary between 5 and 10% of the fill weight and processors arbitrarily add excess raw material to compensate for this loss which often end up in more quantity than what is really required. The excess thus wasted is computed to be around 700 tons of shrimp annually. Research has shown that treatment with polyphosphates can prevent drip loss so that the processor need not lose any material to compensate for thaw drip loss.

In the field of canning of shrimp the industry faced several technological problems in the course of its development. Sporadic occurrence of blackening of can and contents, liquefaction of canned material and wide fluctuations in drained weights often caused heavy rejections and consequent loss to producers. Prolonged investigations have now clearly elucidated the reasons for such defects and helped in working out measures to overcome them. The canning industry is today thus equipped to produce goods of standard quality with the result that rejections at the producing end have been substantially reduced.

A variety of canned products. A. Clams canned in brine. B. Froglegs in oil. C. Tuna canned in oil. D. Sardines canned in tomato juce. E. Mussels canned in brine

Improvements in the Microbiological Characteristics of Processed Products and in Environmental Sanitation. Technological research carried out in the country made its most significant impact in the field of fish microbiology and plant sanitation. While in the early stages of development of the shrimp industry plants and processed shrimp products registered very poor levels marked by very high bacterial counts today most of them fall within internationally accepted levels.

This achievement has been the result of constant research efforts supported by persistent extension work.

Product Diversification. As in the case of every developing industry the shrimp processing sector also slowly began to feel the pressure of increasing material cost and processing expenses so that it needed support for stability, which is now considered possible only by product diversification and greater utilization of plant capacity. As a result of researches in this direction methods are now available for canning and freezing of several of the Indian fishes, other than shrimp. Most of the technological problems relating to internal distribution of fresh and

CONTINUED ON PAGE 117

RECENT ADVANCES IN INLAND FISHERIES

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Director, Central Inland Fisheries Research Institute, Barrackpore, West Bengal

THE diet of an average Indian is not only very low in calories; the animal protein component in it is alarmingly deficient. It is estimated that about 8·5 million tonnes of fish is required annually to meet the present day demand of fish protein in India against the current annual total production of 1·7 million tonnes. A five-fold increase in fish production, is, therefore, called for. It is felt that India's marine fisheries, if developed properly, can contribute about 5 million tonnes annually and inland fisheries the remaining 3·5 million tonnes.

Inland fisheries comprise two types of waters, viz. fresh and brackish. Each type of water sustains two categories of fisheries, viz. culture and capture. Available statistics show that 16 lakh ha of culturable freshwaters in the form of ponds and tanks exist in the country, of which 6 lakhs are currently utilised, 4 lakhs are readily available for utilization and the remaining 6 lakhs have to be reclaimed for culture. In the currently utilized freshwater for fish culture, the average yields are reported to be as low as 600 kg/ha/year. The reclamable area comprises swamps and marshes where, even in their present state, scope for culturing air-breathing fishes exists. In respect of brackishwater culture fisheries, while 20 lakh ha are estimated to be available in the country, their present day utilization is negligible.

The country's capture fishery resources comprise 29 lakh ha of reservoirs and lakes, whose utilization is only partial with yields averaging only 5-8 kg/ha. India is estimated to have 27,359 km of rivers, inclusive of their main tributaries. The yield from fluviatile fisheries of Indian rivers is very low except in years of bumper hilsa catches and that too only in zones of the natural occurrence of the fish. The network of irrigation canals and channels criss-crossing the whole country runs into 112,654 km in length. The utilization of canals for fish production in the country is at present negligible. Estuaries, brackishwater lakes and backwaters of India comprise a total of 26 lakh ha. The production from open estuaries at river mouths is very poor. Although brackishwater lakes, such as the Chilka and the Pulicat and backwaters of Kerala, etc., yield better catches, considerable scope for enhancing fish production exists through proper development. The Sunderbans area of West Bengal covering 2,330 sq km comprises a network of brackishwater creeks and canals where mangrove swamps abound. Great scope for developing the Sunderbans into productive fisheries exists.

Freshwater Fish Culture

Recent years have witnessed far reaching changes in the techniques of freshwater fish culture. These mainly pertain to (i) technique of production of fish seed essentially required for stocking India's culturable waters; (ii) techniques of preparation and management of nursery, rearing and stocking ponds and (iii) introduction of composite fish culture, which, in essence, enlarge the scope of mixed farming by adding to the cultivated Indian major carps certain fast growing exotic species of fish, notably the grass carp, silver carp and the common carp.

As the Indian major carps do not naturally breed in confined waters, their young ones have to be collected from rivers and streams with the attendant uncertainty of spawn quality and quantity in the collections. The practice of bundh breeding of carps—a monopoly of West Bengal until some time ago—has recently been extended to Madhya Pradesh and is seeking to spread in other States as well. However, a real breakthrough in inland fish seed production technique occurred when injections of pituitary gland extract of maturing carps brought about fish breeding in ponds. This epoch-making development took place at the Cuttack Sub-station of the Central Inland Fisheries Research Institute in 1957, since when the technique has not only been vastly improved but its use spread widely in the country. The Chinese carps have also been successfully bred in 1962 by adopting similar techniques. Pituitary breeding of carps provides a dependable source of pure seed of cultured species and furnishes a handy tool for selective breeding and hybridization—an instrument which in respect of agriculture has made green revolution possible. Selective breeding and hybridization provide means of stock improvement with tremendous potential and pave the way for a revolution in fish culture.

The last two decades have witnessed great strides in the preparation and management techniques of nursery, rearing and stocking ponds. Research on the subject has revealed that preparation of nursery and stocking ponds should comprise—(i) eradication of predatory and weed fishes before stocking; (ii)fertilizing and manuring the pond aiming at sustained production of plankton to serve as food for the stocked seed; (iii) control of algal blooms; (iv) control of predatory insects and frogs; (v) artificial feeding and (vi) improvement of pond hygiene in general.

Recently the use of growth promoting substances in fish nurseries has led to a production of 4 to 5 million, 20 to 30 mm long carp fry/ha in two to three crops of 15 days' duration each, as against a meagre production of 20,000 to 40,000 fry/ha obtained by conventional methods. Field experiments have also shown that by improving the technique of carp fingerling rearing, about 80,000, 10-15 cm long fingerlings/ ha can be raised with a survival of 80% and a production of about 3,000 kg/ha within 3-6 months. By composite culture of Indian and exotic carps and under proper management, a maximum production of 4,210 kg/ha/year (average 3,062 kg) have been obtained as against the known average figure of about 600 kg/ha/year for the whole of India. By further improvement of management such as continuous harvesting, intensive fish feeding and introduction of water circulation, a production of 10 tonnes/ha/year is within realisation.

Recent success in inducing major carps to breed twice within a period of two months is considered to be very important. Further research in this line may lead to multiple spawning and domestication of the Indian major carps. To meet the growing demand of pituitary extract, essentially required for induced fish breeding, a technique of preserving pituitary extracts in glycerine and ampouling thereof has been developed at the Cuttack Sub-station of the Central Inland Fisheries Research Institute, which is a step towards establishment of "PITUITARY BANK" to serve as a readily available source of injection material. A discovery of phytophagous habits of the tadpoles and adults of *Rana hexagdactyla* of West Bengal is considered to be a very important finding in the field of frog culture in India.

Brackishwater Fish Farming

As stated above, the culture fisheries resources of the brackishwaters of India surpass in magnitude those pertaining to freshwaters. Very little of this vast fishery resources is currently being utilised. In essence, brackishwater fish farming as practised now, comprises culture of fish in tidal waters admitted through sluices in suitably embanked enclosures called 'bheries' in Bengal. Fish that are cultured in such impoundments are generally euryhaline forms which can naturally tolerate wide changes in water salinity, the kind of environment which tidal waters in estuaries present. The tide, in proper seasons, usually carries along with it seed of euryhaline species and hence, intake of tidal water in a 'bheri' through sluices serves the double purpose of intake of water as well as the fish seed for culture. Such a fishery (called 'bhasa-bada' fishery in Bengal) does not need much capital investment. It involves only construction of embankments and ereation of sluices. A 'bhasa-bada' fishery generally involves little digging. In a fishery of this type, however, the seed of desirable as well as those of uneconomic species and the predatory fish get inside the impoundment and the ultimate yield from the fishery is the net result of the survivors grown over the duration the season lasts. The skill of the operator of a 'bhasa-bada' fishery lies in the timing of the tidal intake and the income the owner makes depends on the seed conglomeration that goes in the fishery. It is obvious that no steady income is possible when chance plays a dominant role in the operation of the fishery. Modern coastal aquaculture seeks to do away with uncertainties of fish production. It entails construction of a proper farm incorporating nurseries, rearing ponds and stocking ponds. It also entails selective stocking of compatible species of fish in appropriate densities and adoption of proper nursery management and rearing practices. It involves pond fertilization of feeding so that a predictable harvest can be obtained. Coastal aquaculture, therefore, has all the problems similar to freshwater pisciculture as an industry.

A brackishwater fish farm of the Central Inland Fisheries Research Institute has been constructed at Kakdwip, West Bengal, in which experimental studies on nursery management, fish farm management techniques and acclimatisation studies are in progress. It is expected that techniques will be developed to produce 1 tonne of fish per ha per year in due course of time.

Brackishwater areas are yet subject to another type of fish farming termed polyculture comprising, in essence, mixed farming of fresh and brackishwater species of fish. India's know-how of freshwater fish farming is appreciable. This is, however, not the case with true brackishwater fish farming. Polyculture differs radically from true brackishwater fish culture of the 'bheri' type. Here, there are no sluices and no mechanism for tidal water intake. It is in fact a culture of compatible fresh and brackishwater species in waters of low salinity. When brackishwater areas are reclaimed for construction of sky ponds, their desalination takes a long time and for many years such waters retain low salinity. These ponds prove congenial for mixed culture of such freshwater fish as can grow in waters of low salinity and of brackishwater fish with wide salinity tolerance. With lapse of time, however, such ponds will eventually become true freshwater ponds.

In the field of capture fisheries of the country's inland waters, while the riverine and estuarine fisheries need to be conserved they may, by and large, continue to serve the present day subsistence level of fish production and the little marketable surplus they produce, any further augmentation of yield from them is not only time consuming but also not commensurate with the effort and expense necessary for their development. Application of laws of capture fishery management based on studies of population dynamics of fishes involving effort and mesh regulation, no matter how brilliantly formulated by scientists, among the uneducated and poor fishermen population of India, is of doubtful utility.

Despite the development of induced breeding technique through pituitary hormone administration, the culture fishery of India is mainly dependent upon the riverine fisheries, as the supply of fish seed of carps is mainly drawn from riverine sources. This fact places the riverine fishery of India at a position of great importance and any depletion of riverine stocks, should it occur, will bring about far reaching consequences on the entire freshwater fish production of the country. In any case depletion of riverine fisheries has to be prevented. It is, therefore, necessary to strictly enforce measures for conservation of the natural fish stocks of Indian rivers and estuaries.

During the period 1964-70, 107 centres on different rivers of the country, viz, Ganga—6, Yamuna—23, Rapti—1, Brahmaputra—3, Banas—3, Cauvery—7, Kosi—4, Sone—14, Godavari—4, Tungabhadra—3, Vedavati—1, Ramganga—2, Tons—1, Ken—1, Narbada—1, Mahi—1, Vanivilas sagar—1, Bhima—1, Khanua Kosi Dhar—6, Coleroon—2, Beas—1, Sutlej—4, Ghagra—11, Burhi Gandak—1, Badua—1, Gomti—1, Mahananda—1, Parvati—1, and Kansabati—1, in the States of Assam, Bihar, Bengal, Uttar Pradesh, Rajasthan, Haryana, Punjab, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu and Mysore were prospected for the availability of carp spawn. Spawn capture studies in rivers have brought out the importance of mesh of net, quality and quantity of silt in the river and velocity of current in riverine spawn collection. At each site spawn of good quantity is available only when the flood reaches a particular height. On windy days spawn is not collected in the nets to the extent it is during calm or drizzling weather conditions.

Breeding of hilsa by stripping has been repeatedly achieved at the Allahabad Sub-station of the Central Inland Fisheries Research Institute. The rearing of hilsa in ponds has also been achieved and hilsa have attained over 2 years of age in ponds. This important development tends to make hilsa a culturable species of fish. It will also enable production of hilsa seed to restock the rivers, where on account of dams, the hilsa fishery have sustained severe loss.

The Central Inland Fisheries Research Institue has, in 1971, started four All-India Co-ordinated Research Projects in fields of great developmental significance. The subjects are—(i) Composite culture of Indian and exotic fishes; (ii) Propagation and stocking of seed of air-breathing fishes for culture in swamps; (iii) Investigations on riverine carp spawn prospecting and collection techniques and (iv) Studies on the ecology and fisheries of freshwater reservoirs. It is hoped that the Co-ordinated Research Projects with their attendant adaptive research will show the way to fuller utilization of India's ponds and tanks—its swamps and marshes and its reservoirs and lakes.

CONTINUED FROM PAGE 114

TECHNOLOGICAL RESEARCH IN INDIA'S FISHERIES DEVELOPMENT

preserved fishes are either solved or nearing solution through the operation of All-India co-ordinated research project on fresh fish transportation—thus providing the fish processing industry with a strong domestic base in support of its export activities.

Side by side with development new and improved methods for processing different types of products like canned, frozen, cured, dehydrated and accelerated freeze-dried products, efforts were concentrated towards developing essential machinery and equipment for the processing industry, for evolving methods for utilization of processing factory wastes and economic utilisation of cheap varieties of fishes. Significant advances made in these directions are expected to support the industry in its future expansion. Commercial types of dryers have been evolved for production of dried fish products of improved quality. A variety of products for human consumption could be evolved from trash fish, chief among them being fish wafers, fish noodles, soup powder, high energy foods and fish protein concentrate each of which holds out possibility of commercial exploitation especially to solve the problem of protein malnutrition in the country. Trials with products like chitosan developed from prawn shell wastes have shown promise of proper utilisation of most of the processing factory wastes so as to relieve the industry from the strain of increasing cost of production of the main products.

COMPOSITE FISH CULTURE IN INDIA

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All-India Co-ordinated Project on Composite Culture
of Indian and Exotic Fishes,
Central Inland Fisheries Research Institute
Barrackpore, West Bengal

COMPOSITE fish culture is the combined or mixed farming of compatible fish species. This association of species with non-competitive feeding habits results in fuller utilization of fish food and space available in ponds. The main objective of composite culture is to select and stock fishes feeding in different zones of water so as to exploit all the food chain present in water and thus increase the fish production. Monoculture in freshwater stagnant ponds is not very popular now. Most Asian and Far Eastern countries have taken up composite culture mostly on the line of the Chinese system of mixed fish farming though, with certain modifications, so as to suit the local demands. The composite culture of four species of Chinese carps is still being practised by the Chinese fish farmers. The four species of carps are:

1. Grass carp (*Ctenopharyngodon idella*), which feeds on aquatic macrophytes and grass.
2. Bighead carp (*Aristichthys nobilis*), which feeds on macroplankton.
3. Silver carp (*hypophthalmichthys molitrix*) which feeds on microplankton.
4. Common carp (*Cyprinus carpio*) which is an omnivore and bottom feeder.

The most favoured species in India for composite fish farming are the Indian major carps, *Catla catla*, a surface feeder which feeds mainly on plankton, *Labeo rohita*, a column feeder feeding on algal forms and decaying macrophytes and *Cirrhinus mrigala*, a bottom dweller subsisting mainly on semi-rotted vegetable matter and detritus. Recently, exotic carps, common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) have also been included in the mixed culture.

Since 1950, experiments have been carried out on different aspects of composite fish culture at the Pond Culture Division of Central Inland Fisheries Research Institute. Besides Chinese carps and common carp, other exotic species have also been tried in combination with indigenous species. From 1957-61, *Tilapia mossambica* in combination with a limited number of major carps yielded an average production of 2,203 kg/ha/year without any fertilization and supplementary feeding, but with proper fertilization and supplementary feeding, an estimated yield of 4,870 kg/ha/year has been produced. Later as it was found to compete with major carps, *Tilapia* was dropped out from the list. In 1962-63, some preliminary short-term experiments

TABLE 1. STOCKING DENSITY AND COMPUTED PRODUCTION IN SHORT-TERM EXPERIMENTS CONDUCTED AT CUTTACK

Stocking/ha *No.*	*Wt. (Kg.)*	*Size of pond (ha)*	*Period of growth (days)*	*Computed Production (Kg/ha/yr)*
3,750	300–500	0.04	52	1,925–4,900
2,000	162–190	0.04	60	1,000–1,800
5,000	42.5–50.0	0.04	93	2,478–3,059
3,075	375–425	0.04	97	2,500
690	1,040–1,100	0.08	90	1,900–2,850
2,500–5,000	2.85–5.7	0.04	90	700–1,300
4,875–5,000	600–650	0.04	100	3,400–4,900
3,750	350	0.04	195	3,338
5,575	384–448	0.04	195	2,433–4,352
15,000	1,500	0.08	270	4,284–4,600
12,800	790	0.04	365	3,167
4,700	326	0.04	365	2,738

were again conducted on composite culture of Indian exotic carps for varying duration. Of these, only 2 were of 365 days' duration, one of 270 days' duration and the rest of 52-195 days' duration. The details of stocking density and computed production obtained in these experiments are summarised in Table I.

These experiments also showed that of various combinations tried, grass carp-silver carp combination is superior to grass carp-catla, and that grass carp-silver carp-common carp combination is superior to grass carp-catla and common carp. In most of the experiments, silver carp grew faster than catla and accounted for appreciable share in the yield. Of the 20 experiments conducted during the 1963-68 period on production of table-sized fish through composite fish farming under three broad categories viz. (i) culture of Indian carps alone, (ii) culture of exotic carps alone and (iii) culture of Indian and exotic carps together, in as many as 16 cases, the actual annual production of fish per ha obtained was above 2,000 kg, in 14 cases it was above 2,500 kg, in 5 cases it was above 3,000 kg, in 3 cases it ranged above 3,500 kg and the highest obtained was 4,210 kg. The gross annual production per ha was 1,439–2,975 kg (average 2,088 kg) with major carps alone, *c.* 2,900 kg with exotic carps alone, and 2,234–4,210 kg (average 3,085 kg) with the combinations of Indian and exotic carps.

Experimental ponds were regularly fertilized with cowdung and inorganic fertilizers comprising ammonium sulphate, superphosphate and calcium ammonium nitrate in varying quantities. Fishes were fed with rice bran and mustard oil cake (1:1 by weight). Grass carp were fed with aquatic weeds, such as *Spirodela*, *Lemna*, *Azolla*, *Hydrilla*, *Ceratophyllum*, *Najas*, etc.

Catla, rohu, and mrigal were stocked at the rate of 5,000 per ha in 1:1:1 ratio. But when Indian carps were combined with exotic species, the combination was as follows: catla 2 : rohu 6 : mrigal 2.5 : silver carp 5 : grass carp 2 : common carp 2.5 and gourami 0.3 with a stocking density of 5,075 fingerlings per ha. Thus, these experiments have demonstrated that with judicious stock manipulation of Indian and exotic species, production of marketable fishes may be increased from the average production of 600 kg/ha/year in usual pond fish culture to the extent of 3,000 kg/ha/year.

When the economics of mixed farming on the basis of the above stated experiments was worked out in terms of expenditure incurred and total return of fish, it is expected that annual income may roughly range between Rs 7,000 to 12,000 per ha of water, whereas, available figures on agricultural production and economics show a net annual income per ha in the range of Rs 4,000 to 9,000 only (net income/ha/year for rice is Rs 8,752, for potato it is Rs 4,334 and for jute Rs. 5,909). Thus the net income range in mixed culture is quite lucrative.

With the success achieved at the Central Inland Fisheries Research Institute, an All-India Co-ordinated Project on 'Composite Culture' of 'Indian and exotic fishes' was started by the Indian Council of Agricultural Research, to try this under different soil conditions. Six centres one each in Andhra Pradesh, Haryana, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal have been started. The centres are located in Sunkesula Fish Farm (A.P.), Saidpura Fish Farm (Karnal, Haryana), Hadapsar Fish Farm (Poona, Maharashtra), Bhavanisagar (Tamil Nadu), Gujartal Fish Farm (Jaunpur, U.P.) and Kulia Fish Farm (Kalyani, West Bengal). The work was started in late 1971 and yet, the results obtained are very encouraging. For example, in Kulia Fish Farm, 4 ponds have been stocked, two each with catla, rohu, mrigal in the ratio of 4 : 3 : 3 and another two with catla, rohu, mrigal, grass carp, silver carp and common carp in the ratio of 1 catla : 3 rohu : 1.25 mrigal : 2.5 silver carp 1 grass carp : 1.25 common carp. The ponds have been stocked at the rate of 5,000 fingerlings/ha and the stocking size of the fish is about 100-150 mm in total length. In about 2 months period with proper fertilization and supplementary feeding an assessment of growth of fish revealed a standing crop of about 275 kg in a 0.23 ha pond, 130 kg in 0.15 ha and 153 kg in another 0.15 ha pond and 135 kg in 0.13 ha pond. The last two ponds contain Indian and exotic carps. Although all the fishes have shown a good growth, grass carp has shown a growth of 365 mm in length and 508 gm in weight in two months. In Malacca (West Malaysia), when grass carp, silver carp and bighead were grown together, bighead showed much faster growth and therefore proposals for importing it from South East Asia are afoot. This species also should be included in composite fish culture and it may well be a beneficial mumber of the association. Thus, the results obtained so far in the experiments conducted on composite culture can be considered as very encouraging and are definitely an indication of a major breakthrough in fish production in our country, at least 5-8 times more than what we get by the traditional methods.

GROW MORE

MARKET MORE

PROGRESS OF FISHERIES RESEARCH IN RESERVOIRS

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The Central Inland Fisheries Research Institute has been engaged in Reservoir Fisheries Research since 1958. A Reservoir Fisheries Station was established at Tungabhadra dam (Mysore State) and the studies pursued up to 1967 when the research station was shifted to Hazaribagh to cover Konar and Tilaiya reservoirs. In addition, investigations are also in progress covering a few small impoundments in Madhya Pradesh. Besides the above, limnobiological surveys were carried out in Vanivilasagar reservoir in Mysore State and a few reservoirs in Bihar, among which Nalkari reservoir merits particular mention. An All India Co-ordinated Research Project on Ecology and Fisheries of Freshwater Reservoirs in India was launched in 1971 covering Bhavanisagar (Tamil Nadu), Nagarjunasagar (A.P.) Tenughat (Bihar), Rihand (U.P.) and Bhakra (H.P.).

Reservoir Ecology

The reservoir eco-system is unique. The water regime oriented to the multipurpose character of the reservoirs has great impact on the dynamics of nutrient cycles, heat budget, productivity and biotal characteristics of impounded waters. A correct understanding of the ecology of reservoirs is therefore *sine qua non* for scientific management and development of reservoir fisheries.

The studies carried out by CIFRI on Nalkari reservoir and Konar and Tilaiya, all the three belonging to Damodar river drainage but at different phases in time series bring into focus the limno-biological and limno-chemical changes a reservoir passes through from the time an impoundment is 'closed' through subsequent years. Nalkari reservoir, a new impoundment, represents a stage of 'initial high productivity' and this is attributable to the fact that when the terrestrial areas with rich top soil, trees, shrubs and other organic matter are submerged, consequential to dam construction, the water gets enriched in nutrients from organic decomposition and from leaching of the inundated soil. This results in great oxygen demand from increased microbial activities. During this phase there is a rich development of plankton. These aspects fully reflected in the case of Nalkari reservoir and applicable to other reservoirs in India have great management implications in the scientific development of reservoir fisheries in India.

Depth-oriented physico-chemical aspects of water especially with reference to temperature, turbidity, pH, alkalinity, dissolved oxygen, dissolved free carbon dioxide, nitrate, nitrogen, dissolved inorganic phosphate, calcium and magnesium, silicate and specific conductivity were studied in detail for Tungabhadra reservoir, DVC reservoirs (Konar and Tilaiya) and Nalkari reservoir. These studies have shown that some of the chemical parameters may be useful in evaluating the productivity of reservoirs. Of the reservoirs studied by CIFRI, Nalkari reservoir may be considered 'average' and Tungabhadra, Konar and Tilaiya 'sub-average' from productivity point of view. In Nalkari reservoir, there is thermal stratification in summer (31° C surface and 22° C at 14 m depth). In addition there is chemical stratification in PH (8.3 at surface and 7.0 at 14 m depth), dissolved oxygen (7.6 ppm at surface and 0.9 ppm at 14 m depth), in free Co_2 (nil at surface and 9.0 ppm at 14 m depth) and bicarbonate alkalinity (46 ppm at surface and 55 ppm at 14 m depth). In Konar though there is thermal stratification in summer (27° C at surface and 18°C at 24 m depth) there is no analogous chemical stratification. In Tungabhadra there is neither thermocline nor chemocline though it is superior in bicarbonate content and specific conductivity (240-493 × 10—6 mho). The above physico-chemical parameters provide the much needed indices for evaluating the productivity of our reservoirs and these have great biological significance. For more precise results the above parameters should be evaluated in conjunction with specific conductivity and primary productivity observations. The lower values of primary productivity in Konar reservoir (211 mg C/m^3/day) and specific conductivity (100×10—6 mho) corroborate the above trend. The thermocline has been observed for DVC and Nalkari reservoirs only in summer while in other seasons the water temperature is more or less uniform in depth profile. This physical phenomenon facilitates mixing of water layers and is conducive to enrichment of trophogenic zone.

The phyto and zooplankton occupy important places in the tropic dynamics of reservoir ecosystem. The phytoplankton is represented by myxophyceae, chlorophyceae and diatomaceae. The myxophyceae is predominant in Konar, Tilaiya, Govindgarh and Rihand reservoirs. The Govindgarh reservoir makes a departure from the above trend and here the zooplankton is predominantly represented by protozoa followed by rotifers and crustacea. The physico-chemical conditions such as temperature, turbidity, phosphate, nitrate and silicate seem to influence the plankton abundance in general. The zooplankton shows a general peak in summer months.

Dipteran insects mayfly nymph oligochetes, gastropods and bivalves represent the bottom biota. In Tungabhadra reservoir molluscs were dominant while it was insects in Konar, Tilaiya, Govindgarh and Rihand. The studies carried out point to the fact that drawdown has unfavourable impact upon bottom fauna. In Tungabhadra reservoir the bathymetric distribution of benthos revealed that insects prefer a depth range of 4 to 8 metres and molluscs depths less than 13 metres.

Periphyton on submerged tree stumps studied for the first time in Konar and Tilaiya reservoirs revealed the presence of algal complex comprising filamentous green algae, blue green algae, and diatoms. The studies further showed that periphyton biomass was more in deep zone.

Fish represents the terminal product in any aquatic eco-system. It is necessary to have a correct understanding of the feeding habits of indigenous fishes so that they could be classified as those on 'short food chain' and those on 'long food chain' as this has a bearing on rational managemement of fisheries in reservoirs. Studies carried out by CIFRI in Tungabhadra, Konar, Tilaiya and small impoundments in Madhya Pradesh have thrown considerable light on this aspect and are of great ecological and management interest. These studies have shown that many are euryphagic, some stenophagic and a few monophagic. Many are herbivorus and detritophagic like *Puntius kolus, P. dobsoni, P. sarana, P. pulchellus; Labeo fimbriatus* is phytoplanktophagic; *L. calbasu, L. bata, L. rohita* and *Cirrhiha mrigala* are detritophagic and phyto-planktophagic: *Catla catla* is zooplanktophagic. *Tor khudree, T. mussulah, Notopterus notopterus, Pseudeutropius taakree* and *Mystus cavasius* are carnivorous (feeding on invertebrates); *Mystus seenghala, M. aor, W. attu, Silonia childrenii* are predatory (feeding chiefly on fish).

In Tungabhadra weed and trash fishes, namely, *Puntius sophore, P. ticto, P. amphibius, Aspidoparia morar, Oxygaster* spp., *Rasbora daniconius, Chela atpar, Glossogobius giuris, Osteobrama* spp. are well-established. In Konar and Tilaiya reservoirs *Ambassis nama, Osteobrama citio, Esomus danrica, Amplypharyngodon mola, Puntius stigma, P. ticto, Oxygaster bacaila, O. phulo, Laubuca laubuca, Barilius barna* and *B. barila* are well-entrenched. *Ambassis nama* and *O. cotio* compete for food with the economic catla while some of the other trash fishes compete with other major carps. Many of the larger species of catfishes being carnivorous and predatory and trash fishes being competitive with major carps for food and with lower efficiency of food conversion were responsible for the lower production and yield in Tungabhadra, Konar and Tilaiya reservoirs.

Fish Production in Reservoirs

For rational fishery management it is necessary to have proper assessment of fish production. Assessment of fish production necessarily involves studies on standing crop, growth rate, fishing and natural mortality and recruitment. Data on the biology of commercial fishes of Tungabhadra, Konar, Tilaiya and a few smaller impoundments of Madhya Pradesh are now available for *Puntius dobsoni, P. kolus, P. sarana, Labeo fimbriatus, Osteobrama vigorsii, Mystus seenghala, M, aor, W. attu, Silonia childrenii, Pseudetropius taakree, C. catla, L. rohita, L. calbasu, C, mrigala* etc. in respect of age, growth, food and feeding, maturity, fecundity etc. Due to selective samples from gill nets which are the dominant gears in the reservoirs studied, not much progress could be made in evaluating certain population parameters like mortality rate. Efforts are now in progress in evolving suitable sampling gears for the above purpose. The present yield from the Indian reservoirs are far from satisfactory. It is 6·2 kg/ha in the case of Tungabhadra reservoir, 6·4 kg/ha in Konar, 6·5 kg/ha in Tilaiya, 13 kg/ha in Bhavanisagar, 16·4 kg/ha in Rihand, and 4 kg/ha in Nagarjunasagar, the last three representing the Coordinated Project Centres. At present the yield-production ratio is unfavourable due to wrong management measures and irrational fishing. A target of 40 kg/ha is easily attainable if our reservoirs are scientifically managed. We have at the moment an estimated 12,00,000 ha of water area under impoundments. These should normally provide half a million tonnes of fish.

Flock of cross-bred ewes produced by crossing Malpura, Chokla and Jaisalmeri with Rambouillet

PROGRESS IN SHEEP GENETICS AND BREEDING RESEARCH

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SHEEP plays an important role in the economy of Indian Agriculture especially in arid and semi-arid areas with marginal and sub-marginal lands unfit for crop cultivation even using more modern agricultural techniques like dryland farming. According to 1966 livestock census, India has 42 millions of sheep producing about 35 million kg of wool and about 0.112 million tonnes of meat in addition to skins, manure and other by-products and ranks the fifth largest nation of the world with regard to sheep population. The major portion of the Indian wool is of coarse and carpet quality. About 6-7 million kg of this wool is reportedly used for apparel manufacture within the country and large quantity of this wool is exported as raw wool, tops and manufactured goods earning around 237 million rupees in foreign exchange. India is importing nearly 21.65 million kg of raw wool, tops and shoddy worth Rs 172 million. The availability of fine wool considering both produced indigenously and imported is far below the requirement of the installed capacity in worsted sector. Out of the total meat produced from livestock other than poultry, mutton constitutes 17.3% and comes next to the goat meat (35.1%). In addition to internal consumption there is great scope for export of sheep and goat carcasses especially to Middle Eastern countries. During 1966-67, 6800 ewes and lambs worth Rs 5,00,000 were exported.

Considering the agro-climatic conditions, the type of sheep and their population, the country can be divided into four regions (i) Northern temperate region with approximately 5 million of medium to fine wool producing sheep, (ii) North western region with 13 million sheep producing carpet quality wool except Chokla which produces medium to fine fleeces. This region is mostly arid or semi-arid and carries 25% of the sheep population which contributes more than 50% to the total wool produced. (iii) The peninsular region with 21 million sheep, of which 10-12 million produce no wool and the others produce very coarse and coloured fleeces and (iv) the Eastern region with only three million sheep mostly maintained for meat.

During the last 20 years there has been decrease in the sheep population in some of the states like Andhra Pradesh, Gujarat, Kerala, Tamil Nadu, Mysore, Punjab and West Bengal and there has been increase in other states such as Assam, Bihar, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Uttar Pradesh and Himachal Pradesh. The decline in sheep population can be attributed primarily to the increase in land put under agriculture farming and possible emigration of sheep to adjoining states. The largest increase has been in Rajasthan. A similar trend as for sheep population has been observed in wool production except in Tamil Nadu where wool production has virtually remained static and in Rajasthan where there has been increase higher than expected from the increase in sheep population and is due to improvement in wool production per sheep.

India possesses 24 distinct breeds of sheep of which 5 can be classified into medium to fine wool, 14 into coarse carpet quality wool breeds and rest into hairy meat type breeds.

Before launching any improvement programme through genetic engineering (selection and mating system), it is necessary to have the knowledge of the phenotypic and genetic parameters like phenotypic means and variances and heritabilities of and genetic and phenotypic correlations among various characters of economic importance. Similarly, knowledge about the consequences of crossbreeding especially the heterosis, general and specific combining abilities, reciprocal effects, the native and exotic breeds to be used in crossing and level of exotic inheritance (grade) coming closest to the desired goal is necessary.

In this article work done in India during the last 25 years on the various aspects of sheep genetics and breeding has been reviewed.

Studies on the Genetic Aspects of Purebred Performances of Native Breeds. Work on the performance of native breeds of sheep has primarily been carried out under I.C.A.R. Scheme, "Improvement of sheep on regional basis" and some other ad hoc schemes (Khera, 1965, Bhasin, 1964, 1969; Bhasin and Desai 1965, 66; Bhasin *et al.*, 1968; Sahni, 1969; Malik, 1970; Balaine *et al.*, 1970, 71; Chopra and Acharya, 1971a, Acharya and Malik, 1972).

Phenotypic averages of production traits. Information available on the performance of native breeds is scanty. Growth studied as body weight at different ages indicate that the performance of native breeds is poor. Out of the native breeds, carpet wool breeds especially Magra have higher body weights. There was nothing gained by crossing carpet wool breeds with the mutton type breeds in body weight gains, efficiency of feed conversion and carcass yield. The averages for wool yield, average fibre diameter, staple length and medullation percentage in the carpet wool breeds ranged from 1.1 to 1.97 kg; 28.48 to 50.56 micron, 4.99 to 1.0 cm (six month clip) and 18.74 to 89.14 per cent respectively.

The survivability of most of the native breeds both as lamb and adult is low. Similarly reproductive efficiency of the native breeds is poor considering the age at puberty, age at first lambing and lambing percentages.

Genetic Parameters

The heritability estimates of weights from birth to one year were moderate to high except for birth weight. The heritability estimates of body weights showed a tendency to increase with age. This may be due to the large maternal effects, especially the dam's milk yield influencing the earlier weights. Genetic and phenotypic correlations among these body weights are large and positive except genetic correlations of birth weight with later weights. Considering the estimates of heritabilities of and genetic and phenotypic correlations among body weights at different ages, it can be concluded that six month body weight would provide the best selection criteria for improving market weight (9-12 month body weight) and adult body size.

Heritability estimates for greasy fleece yield were low except for the second six monthly clip obtained in Nali and Lohi. Heritability estimates for average fibre diameter, staple length and medullation percentage vary from low to very high. However estimates with lower standard error reflect that these characters are moderate to highly heritable. Most of the phenotypic correlations between greasy fleece weight and quality traits and body weights are positive except with medullation percentage. Staple length bears very small correlation with average fibre diameter, percentage true wool and medullation percentage. The genetic correlation of staple length are negative with average fibre diameter and percentage true wool and positive with medullation percentage. Medullation percentage bears positive correlation with average fibre diameter.

Considering the estimates of heritabilities and genetic and phenotypic correlations in the native breeds and estimates available on exotic breeds it appears that selection based on combination of greasy fleece weight and medullation percentage, the former being given a positive weightage and latter a negative weightage would increase the greasy fleece weight and decrease medullation percentage and average fibre diameter and thus improve the yield and quality of the carpet wool.

Selection for Improvement of Purebred Performance. There has been little attempt to improve native sheep through selection except at Sheep Breeding Farm, Poona, Livestock Farm, Hissar, Sheep Breeding Farm, Patna and Sheep Breeding Station, Ootacamund —selection against medullation percentage had resulted in a large decrease in medullation percentage and correlated decrease in average fibre diameter. There have been attempts at selective breeding at some other State Sheep Breeding farms but small number of animals involved, poor recording of performance data and its proper utilisation in selecting prospective breeders has given a feeling that selective breeding has not been successful in bringing improvement in the desired characters. Maximum improvement can be achieved through sire selection as greater percentage of female would be required for flock replacement. With our present primarily nomadic sheep husbandry with individual ownership of small flocks and without ownership of land it will be very difficult to institute any improvement programme in these flocks through selection. The only way possible is through distribution of selected sires and such sires can be produced only in large stud breeding farms with adequate system of recording.

Studies on Cross-breeding Native Sheep with Exotic Sheep. A few attempts at crossbreeding native breeds with exotic fine wool breeds for improving fine wool production in India have been made. Australian Merinos, Russian Merinos, Spanish Merinos, Rambouillet, Polwarth, etc. have been involved in these crosses. Some fine wool breeds are claimed to have been evolved from these cross-breds, the example being the Hissardale produced by interbreeding 7/8th Australian Merino, 1/8 the Bikaneri animals; Kashmir Merino produced by interbreeding 3/4th Tasmanian Merino and 1/4 local; Deccani evolved through interbreeding Merino × Deccani crossbreds and Nilgiris evolved through interbreeding crosses of Cape Merino, South Down and Cheviot rams with Coimbatore.

There are some results available on body weights, wool yield and quality, fertility and survivability of the crossbrds involving different native and exotic breeds and possessing different levels of exotic inheritance. The results are rather sketchy (Tyagi, 1965 Amble and Malhotra, 1966, 1968; Amble *et al*, Kaushik and Singh 1968 and; Annual report 1967; C.S.W.R.I., 1970, 1971). In the majority of cases the animals involved in comparisons are not contemporary and no attention has been given to various environmental factors affecting these characters—in making comparisons. In addition, the number of sires and in most cases even the number of ewes involved in crosses have been extremely small. The result given in various published reports have been reviewed and some conclusions drawn from them are presented as under:

The birth weights of Polwarth × Rampur Bushair halfbreds and 3/4ths and Polwarth × Bikaneri halfbred and 3/4th did not show any significant differences. The adult body weight tended to decline with the increase in the exotic inhertance. Merino × Deccani halfbreds did not show any marked superiority over the Daccanis and were inferior to Rambouillet × Daccani halfbreds which showed 27% superiority over Deccanis. The body weights in general were extremely low. Body weights of Chokla, Malpura and Jaisalmeri crosses with Rambouillet showed that males were in general heavier than the females. Crossbreds were superior to both the parental breeds except in Rambouillet × Chokla (F_1) where the crosses were inferior to Rambouillet. This indicates the exhibition of heterosis for birth weight. There was an increase in birth weight in F_2 compared to F_1. There was increase in birth weight with increase in exotic inheritance. In Malpura crosses however the increase only continued up to 5/8th level. The 3/4th were not superior to halfbreds and were inferior to 5/8ths. Although crossbreds (F_1) exhibited heterosis to some extent for birth weight, there was little loss in this heterosis when crossbreds (F_1) were interbred. This might have been compensated by the larger size and better mothering ability (milk yield) of crossbred mothers. There was increase in the weaning weight of crossbreds over the natives. The weaning weight increased with the increase in the level of exotic inheritance except in R × M crosses where the increase was only up to 5/8th level. Similar trends were also observed for six month and nine month weights. There was increase in adult body weight in crosses over the purebred native. There was however little exhibition of heterosis. 3/4th were inferior to halfbreds in R × C but not so in R × M crosses. In general crossbreds were superior to purebred natives for body weight at all ages. Rambouillet crosses with Gaddi (F_1) were 11% superior in birth weight and 45% in weaning weight to the purebred Gaddi. Corriedale × Coimbatore were superior at all ages up to weaning than Corriedale and Coimbatore except at birth when halfbred were slightly inferiorto corriedale purebred.

The results in general indicate crossbred to be superior to the natives, but the increase in body weights except those in crosses of Rambouillet with Chokla, Malpura and Jaisalmeri at C.S.W.R.I. has not been very large.

Polworth crosses with Rampur Bushair did not produce any marked increase in fleece yield or a decrease in average fibre diameter and medullation percentage. Polworth crosses with Bikaneri showed 65% increase in fleece yield, a slight decrease in average fibre diameter and 45% decrease in medullation percentage. Increase in exotic inheritance has a declining trend on the positive effect of exotic inheritance on wool yield and staple length but an increasing trend in fibre finenesss as reflected by average fibre diameter and medullation percentage.

Deccani crosses with Rambouillet and Merino were markedly superior in wool yield and quality (62 and 39% for wool yield and 22 and 29% for quality). Rambouillet crosses were markedly superior to Merino crosses both in wool yield and wool quality. The wool yield and quality increased with increase in Merino inheritance.

The crossbreds of Rampur Bushair with Rambouillet and Polworth were superior to Rampur Bushair in wool yield and quality (68 and 17% for wool yield and 23 and 12% for quality). Rambouillet crosses were 20% superior to Polworth crosses in wool yield and 13% in wool quality. Increase in Rambouillet inheritance had a positive influence on wool yield and quality.

The performance of Corriedale crosses with Coimbatore showed that there was almost 600 per cent increase in the wool yield, 200 per cent increase in staple length and 100 decreases in average fibre diameter in crosses over Coimbatore. There was exhibition of heterosis in the wool yield although staple length and average fibre diameter of crossbred were only slightly better than the average of the two purebreds.

Chokla purebred produced almost double the wool compared to Malpura and Jaisalmeri. There was 20% increase in R×C (F_1) and 67% increase in R×M (F_1) over Chokla and Malpura respectively. For 3/4ths, the increase was 66% and 152%. Similar trend for first six monthly clip was observed although increase in R x M 3/4ths over Malpura was only 77%. There was marked improvement in wool quality. The fibre diameter and medullation percentage decreased by 14 and 32% and 28 and 66% in R×C (F_1) and R×C (3/4) respectively. Similarly in R×M crosses there was 26 and 42, and 42 and 81 per cent decrease in these two character in halfbreds and 3/4ths respectively. Malpura crosses showed higher gains than the other crosses. R×M (3/4ths) were almost as good as R×C (3/4ths). Results of crossbreeding involving Russian Merinos and some Rajasthani breeds carried out at State sheep breeding farms show a marked improvement in wool yield and quality.

The crossbreds of Polworth and Bikaneri, both half breds and 3/4ths had much higher lambing percentage than both the exotic and native purebreds. Merino × Deccani crossbred and Rambouillet × Deccani crossbreds were inferior to Deccanis. Rampur Bushair crosses were inferior to both the breeds crosses. The 3/4ths were inferior to the halfbreds. The crosses of Chokla, Malpura and Jaisalmeri with Rambouillet were slightly inferior to natives in lambing percentage in February-March lambing season but superior to natives in August-September lambing season. The results on reproductive efficiency of crossbreds are erratic although in majority of cases, the crossbred have shown lower lambing percentages.

The crossbreds showed lesser mortality than the purebred exotics and the natives. The increase in exotic inheritance, as usually known, did not result in higher mortality. Merino × Deccani and Rambouillet × Deccani crossbreds showed similar or slightly lower mortality than Deccani up to weaning. Rambouillet crosses with Rampur Bushair showed lower mortality than Rambouillet but 3/4ths had higher mortality, adult mortality was much lower in halfbreds and 3/4ths compared to purebred Rampur Bushair. The 3/4ths were little inferior to the halfbreds in adult survival. Preweaning survivability was better in crosses as compared with purebred natives, both in Chokla and Malpura crosses. Post-weaning survivability was however slightly better in purebred natives. 3/4ths had slightly lower survivability than halfbreds both in pre-weaning and post-weaning periods. Adult survival was better in Rambouillet × Chokla (F_1) compared with Chokla and Rambouillet × Jaisalmeri (F_1) crossbreds compared with Jaisalmeri but not so in case of Malpura 3/4ths which were far inferior in adult survival compared to halfbreds.

Although most of the animal improvement through genetic engineering is being brought about through selection and appropriate mating systems, interest has recently arisen for determining the possibility of selecting animals on the basis of biochemically polymorphic traits for improving animal production. Research on biochemical polymorphism viz. Potassium Haemoglobin and transferrin types in Indian sheep has been conducted at Central Arid Zone Research Institute, Jodhpur, Haryana, Agricultual University, Hissar, Veterinary College, Mathura, Veterinary College, Bikaner and Central Sheep and Wool Research Institute, Avikanagar (Ghosh *et al.*, 1965; Taneja and Ghosh, 1967; Seth, 1968; Agar *et al.*, 1969; Arora *et al.*, 1970, a, b, c; Arora and Acharya, 1971, 1972, a, b, c, and Arora *et al.*, 1971).

Most of the correlations between biochemical traits and production traits are low and non-significant. Haemoglobin types have been associated with heavy fleeces and low fertility. Individuals with haemoglobin HB phenotypes are reproductively more efficient (Arora *et al.*, 1971). Further they are superior to the individual with AB phenotypes for birth, six monthly and yearling weight and six monthly wool clip. Individual with HK phenotype are superior to individual with LK phenotypes for body weights from birth to 1 year but inferior to individuals with this phenotype for wool yield. Individuals with MB transferring type have the highest yearling weight followed closely by EC and DD types. (Arora and Acharya, 1972a). More work for establishing relationship of biochemically polymorphic traits and production traits is required and has been undertaken under an I.C.A.R. All India Coordinated Research Project on "Blood Groups and Biochemical Polymorphism."

Recommendations

The problem of increasing productivity of sheep in India centres around improving yield of carpet quality of wool of our sheep and making it more uniform, improving the mutton yield of our native mutton breeds especially in the South and developing fine wool and mutton breeds through crossing our native breeds with exotic fine wool (Russian Merinos and Rambouillet) and mutton breeds (Suffolk and Dorset Down) to suit the different agro-climatic regions of the country. The present information indicates that 50% exotic inheritance does not create any problems with regards to survivability and disease susceptibility and shows remarkable improvement in desired characters. It may be desirable to restrict exotic inheritance to 50% under field conditions till the provision of better pastures/ grazing areas and health cover is made. I.C.A.R. has undertaken two large All India Coordinated Projects "Sheep for fine wool "and "Sheep for Mutton" with coordinating and one large unit located at C.S.W.R.I. for both the projects and other units for fine wool located in Himachal Pradesh and for mutton in Uttar Pradesh and Andhra Pradesh. These projects aim at determining the breed combination and level of exotic inheritance which will provide 2.5 kg average greasy fleece yield of 58 is to 64's quality in case of fine wool and 30 kg average liveweight at 6 months of age in case of mutton. Such cross (es) will be interbred to establish new breeds suited for different agro-climatic regions.

In addition to improving the genetic make up of our native breeds through selection and appropriate breeding plans, either to produce more quantities of carpet wool or to produce desired quantity of fine wool or mutton, it is necessary to undertake studies on physiology, nutrition, management, disease susceptibility and disease control of these sheep and also on developing suitable pastures and fodders. In areas under intensive agriculture rather a mutton type or a dual purpose (Corriedale and Corriedale crosses) with high fertility, large growth rate and efficiency of feed conversion, which could provide larger and quicker return through fat lambs production may fit into intensive agricultural farming economy. The availability of such animals will allow a better utilisation of surplus grains and other agricultural by-products available in these areas. Since the improvement in the genetic make up through introducing exotic germ plasm will involve extensive crossbreeding with exotic fine wool and mutton breeds, it will be necessary to maintain large flocks of exotic breeds to provide stud breeding rams. It will be desirable to import exotic stocks from homo-climatic regions. Studies on the causes of deterioration of such imported stocks and possible remedial measures of such imported stock should also be undertaken since it has commonly been observed that imported stocks have shown deterioration over a few generations in this country. Such a deterioration could be to a large extent due to lack of selection, small number of rams used for further breeding, lack of adequate management and nutrition and possibly difficulties in adaptation.

There is also great need for having large sheep breeding farms for producing stud breeding farms of native breeds. The state and Central Sheep Breeding farms at present available have very small breeding stocks and are inadequately staffed with persons trained in Animal Genetics. Little effort in the collection of performance data on different traits which is necessary for obtaining estimates of genetic and phenotypic parameters, needed for developing breeding plans for improvement of these traits, has been made. With the known fertility, survival rates and sex ratio in our native sheep and considering that only 50 per cent of the males available will be above the population mean we will require breeding ewes 8 times the number of stud rams required. This points out to the necessity of having stud ram breeding farms with adequate breeding stocks considering the number of stud rams required and staff adequately trained in genetic and breeding for planning and execution of breeding programmes.

TO AUTHORS

1. *Indian Farming* is a popular, semi-technical journal intended to cater to the needs of progressive farmers, extension workers, agricultural scientists, teachers and students of agricultural research and others interested in new techniques in agriculture.
2. Articles should, therefore, convey proved results of research which would be of practical use to the farmers.
3. In articles on new varieties and techniques, their economics should be given as far as possible.
4. The recommendations should be conveyed in simple language. Tables and charts should be kept to the minimum. The significance of the data should be explained in simple, straight prose. Technical language that would go well with a research article should be avoided while writing popular articles for *Indian Farming*. Weights and measures should be in metric system.
5. The length of an article should be restricted to a maximum of 5-6 type pages in double-space (1500 to 2000 words).
6. The photographs should be clear, relevant to the subject matter and of a minimum cabinet size. The captions should be sufficiently explanatory, and should be written preferably in pencil or typed and pasted on the reverse. The photographs should be properly packed between cardboards to prevent folding and damage in transit. They should not be pasted on the body of the article.
7. Orders for reprints should be placed immediately on the receipt of acceptance. Reprint requirements could be conveyed even while presenting the article.

STEPHANO FILARIASIS IN CATTLE AND BUFFALOES IN INDIA

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About 80 per cent of our agricultural operations are dependent on animal power. This is particularly true of the north-eastern zone of the country comprising Orissa, West Bengal, Bihar, Assam, Manipur, Tripura, etc., where the size of the holdings and the economic conditions of the people do not permit them to take to mechanised agriculture. In this zone the adult cattle suffer from, besides other deadly diseases, a peculiar skin disease called 'Humpsore' caused by a small filarial worm. Though the disease is known as humpsore, in the bullocks, it is very commonly seen on the neck or the yoke, a part which is of utmost importance in this animal. What an udder is to a milch cow, the neck is to a draught animal. When this is affected, the utility of the animal is lost.

As nature would have it, it is only during the rainy season, when the farmer needs his animal most for agriculture operations that this disease appears in cattle, a feature, the Indian farmer can least afford. In his survey of 36,676 animals in the 4 coastal districts of Orissa, Patnaik (1968) reported that the incidence is more in the males than in the females. It ranges from 9.5 to 17.40 per cent in the male and 8.4 to 13.65 per cent in the females. The picture is very much the same in West Bengal, but in certain areas like 24-Parganas it is as high as 21.7 per cent (Chakravarti, 1961). Haldar (1961) reported the incidence in Assam to be as high as 28 per cent in certain areas, adult males being more infected than females. Thus it may be seen that a sizeable number of our cattle population in these areas is affected with this malady. Fortunately, however, this condition is not seen in the cattle of other parts of the country except for a small focus in Kutch district of Gujarat (Pannu, 1958 and Hiregaudar and Chatupale, 1965).

Economic Loss

Although the disease does not kill the animal, it certainly inflicts some damage upon its health. This is reflected in the poor performance of breeding bulls and milch cows. Das (1957) had reported that about 60 per cent of the affected bullocks had the lesion on the neck making many of them incapacitated to either pull the plough or the cart. One of the authors (B.P.) in his personal observations in Orissa from 1958 to 1961 had found that about 10-15 per cent of the affected bullocks had to be rested completely for treatment with the medicines available at that time. This treatment in those days lasted nearly 4 months. Since the socio-economic conditions prevailing in other parts of the north eastern zone being the same, losses would be almost similar. In a modest estimate calculating at the rate of Rs 2 per day per animal towards its feeding and other ancillary charges for a period of 4 months from mid-July to mid-October, the annual loss is estimated to be Rs 2.12 crores on account of bullocks alone. In the cow, though there is difficulty in assessing correctly the loss sustained on account of decreased milk yield, it was estimated to be not less than 50 paise per lactating cow per day during the period when the disease occurs (6 months) and this works up to Rs 2.17 crores. Thus the total loss sustained by the country, directly contributed by humpsore alone, amounts to Rs 4.298 crores, annually. The indirect losses sustained by the farmers which cannot be assessed would even exceed this amount, not taking into account the losses in breeding potential of bulls, particularly the exotic breeds which are more susceptible to this disease (Patnaik, M.M., 1971) and losses on account of damage to the hides.

Realising the economic significance of this disease the Indian Council of Agricultural Research had started schemes to investigate into the various aspects of this disease as early as 1955 simultaneously at Cuttack in Orissa, at Bengal Veterinary College in Bengal and at Khanpara in Assam. The results were encouraging. Based on these results, the Indian Council of Agricultural Research launched an All-India Coordinated Research Programme to investigate into the biology of the causative parasite and evolve suitable control measures against the disease. The three centres under this project are located at: (1) The Indian Veterinary Research Institute (I.V.R.I) Izatnagar, (2) The State Veterinary Laboratory, Bhubaneswar and (3) The IVRI Centre of Andaman Islands at Port Blair. Besides these three centres, the State Government of West Bengal and Assam have their State Units functioning on this problem at Calcutta and Khanpara respectively.

The disease is caused by a thin, small, whitish looking filarial worm called *Stephanofilaria assamensis* Pande, 1936, described for the first time from Assam by Shri P.G. Pande in 1936. The parasite lives inside the layers of the skin only and produces eczema-like lesions. It can occur anywhere on the body of cattle but is

Humpsore-2

usually seen on the neck, hump, and chest mostly.

Subsequent studies on this problem revealed that a fly related to the common house fly, called *Musca conducens* acted as the transmitting vector for the filariid (Srivastava and Dutt, 1963; Patnaik, 1965; Patnaik and Roy, 1966 and 1969). Hence the epizootiology of this disease is directly connected with the fly breeding season and hygiene of the animal sheds.

A second facet of this Project is the disease caused by a similar filariid in the buffaloes. In this the parasite, *S. zaheeri*, Singh, 1958, causes sores on the inner aspect of the ear lobes of buffaloes as a result of which the buffaloes are continuously kept annoyed and restless. Although no systematic survey has been undertaken by any worker, this condition is reported from Assam (Gopalkrishnan, 1949; and Bhattacharjee and Dass, 1967), Travancore Cochin (Menon, 1952), Andhra Pradesh (Singh, 1958; and Ahmed, 1961), Orissa (Patnaik, 1964, and Mishra, 1969). Madras (Anantaraman, 1969), Madhya Pradesh (Dutt, 1970 a; Uttar Pradesh (Dutt, 1970 b) and Andaman and Nicobar islands (Sharma Deorani, 1970). Around Izatnagar this condition is met with in about 1–3 per cent of the buffalo population. But our studies conducted at the local abattoir revealed that the incidence is as high as 7 per cent during the rainy season in buffaloes brought from Haryana, Punjab, Delhi, Rajasthan, Eastern U.P., etc. for slaughter at Bareilly.

Since its distribution is so extensive, unlike humpsore which is confined to the North Eastern zone of the country, its potentialities for spreading are great.

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Humpsore-3

Humpsore-4

Earsore

PROBLEM OF FOOT AND MOUTH DISEASE AND ITS CONTROL

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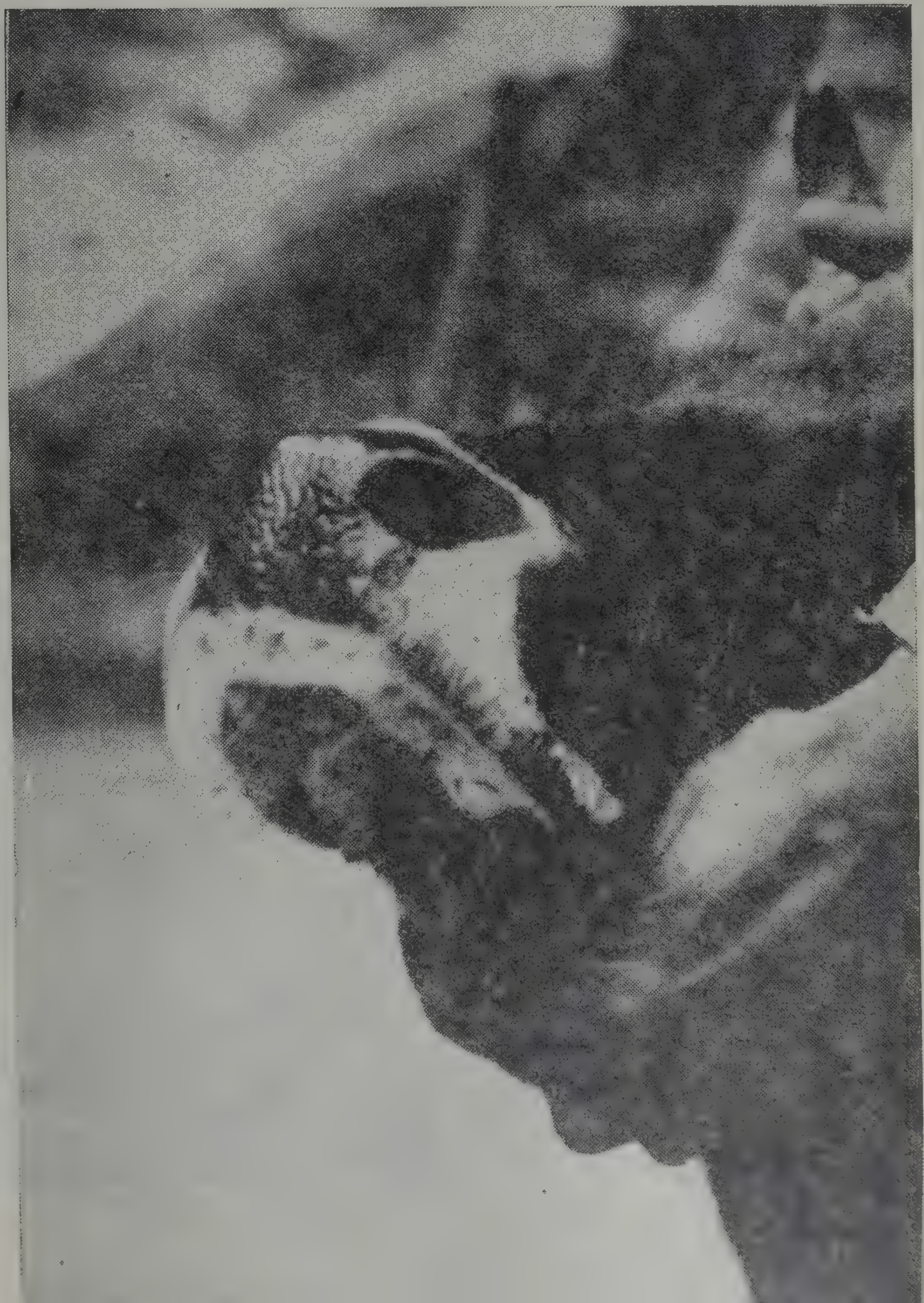
DURING the recent years, the importance of foot-and-mouth disease in a country like India has been very much realized, particularly when the nation is determined to develop intensive cattle-breeding programmes to cope up with deficient milk and butter supply.

Foot-and-mouth disease is a disease of cloven-footed animals. The aetiological agent of this disease is a virus which infects cattle, buffaloes, sheep and goats in the decreasing order. In cattle, drooping of the saliva is the first clinical sign of foot - and - mouth - disease infection. The disease is characterized by the presence of vesicles in the feet and mouth of the infected animals. Other organs such as gums, jaws, cheeks and palate also show lesions. Lesions could also be seen in the udder of heavy-milking cows. On post-mortem examination, lesions could be seen on the pillers of the rumen.

Foot - and - mouth disease virus is infective and highly contagious in nature and shows a considerable degree of resistance to many of the common disinfectants. Foot-and-mouth disease like a wild fire spreads rapidly from infected animals to susceptible animals either by direct exposure or through their secretions which contaminate feedstuff, bedding, stockyard, equipment, transporting vehicles and personnel who carry the virus on their clothes. Infected milk could be an easy source of infection to susceptible calves. This disease causes great economic loss to the cattle industry mainly through the loss in productivity. Among the productive cattle, foot-and-mouth-disease virus causes considerable loss in milk production. In these animals, abortions and sterility may also occur. In certain instances, inflammation of udder may lead to permanent damage of the udder. In bull, loss of hoof and chronic joint infections are well-known secondary complications. Some of the affected animals may become 'panters', the incidence being more in cross-bred animals when compared with the indigenous cattle. Amongst the pure-bred and cross-bred animals mortality in calves may be very high.

One of the major problems posing foot-and-mouth disease control is the multiplicity of its antigenic form. There are seven distinct immunolo-

Fig. 1. First clinical sign of foot-and-mouth disease infection in cattle—dropping of saliva



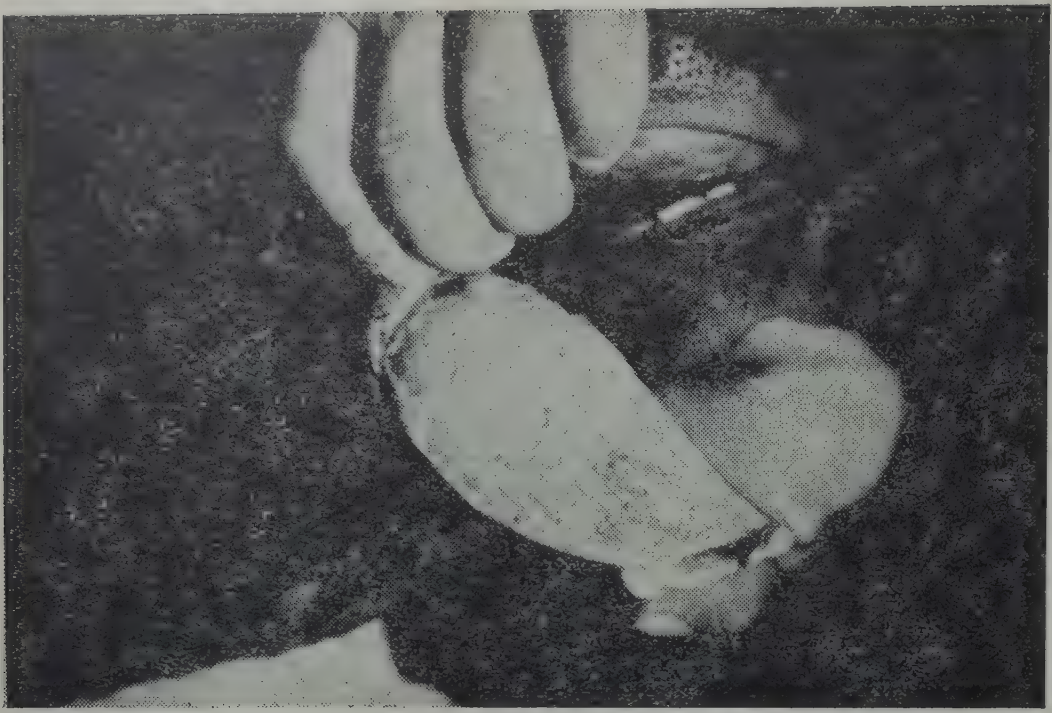


Fig. 2. Erosion of tongue epithilium due to foot and mouth disease

gical types of foot-and-mouth-disease virus. So far, more than 55 subtypes of foot-and-mouth-disease virus have been reported. In India, four types of virus, viz. A,O,C, and Asia I, have been reported to occur. These types are widely prevalent in almost all the states of India.

In order to study the frequency of the occurrence of these types and the subtypes in different parts of the country, the Indian Council of Agricultural Research has launched an All-India Coordinated Project on the epidemiology of foot-and-mouth-disease. Under this project the central laboratory and the project coordinater cell is located at the Indian Veterinary Research Institute, Mukteswar. The regional centres are located one each at Hyderabad, Hissar, Mathura, Poona Calcutta, Gauhati and Madras.

Effective Vaccination

With the information gathered under the project it would be possible to formulate more effective vaccintion programmes. Further, it would also be possible to detect new virus types in time to control them effectively.

At the Indian Veterinary Research Institute, Mukteswar, the diagnosis of foot-and-mouth disease virus can be given within 3-4 hours by the application of direct complement-fixation test, provided the suitably preserved fresh tongue epithelium in sufficient quantity is made available to the laboratory from the infected animals. In the event of insufficient viable material, the diagnosis may take 6-7 days, because the material is to be passaged in laboratory animals like unweaned mice or in living cells contained in test-tubes.

Foot-and-mouth-disease is controlled either by stamping-out policy as adopted by North America and the U.K or by systematic vaccination coupled with appropriate quarantine, sanitary measures and vigorous disinfection as followed in Holland, France and Italy. The former method in which all the infected and in-contact animals are to be sacrificed is heart-breaking and expensive. In India, where foot-and-mouth disease is endemic, systematic vaccination along with strict hygenic measures and prompt reporting appears to be the most promising method to curtail the number of outbreaks.

Extensive research work at this Institute in collaboration with F.A.O. to propagate foot-and-mouth-disease virus in living kidney cells resulted in the development of inactivated tissue-culture polyvalent foot-and-mouth-disease vaccine. As a consequence, in 1966-1967 pilot production of FMD virus in goat kidney cells cultured in large number of Roux flasks was started at this Institute. Now large quantity of this virus is being propagated in these living cells. The virus is collected after 18-24 hours, the time when complete cytopathogenic

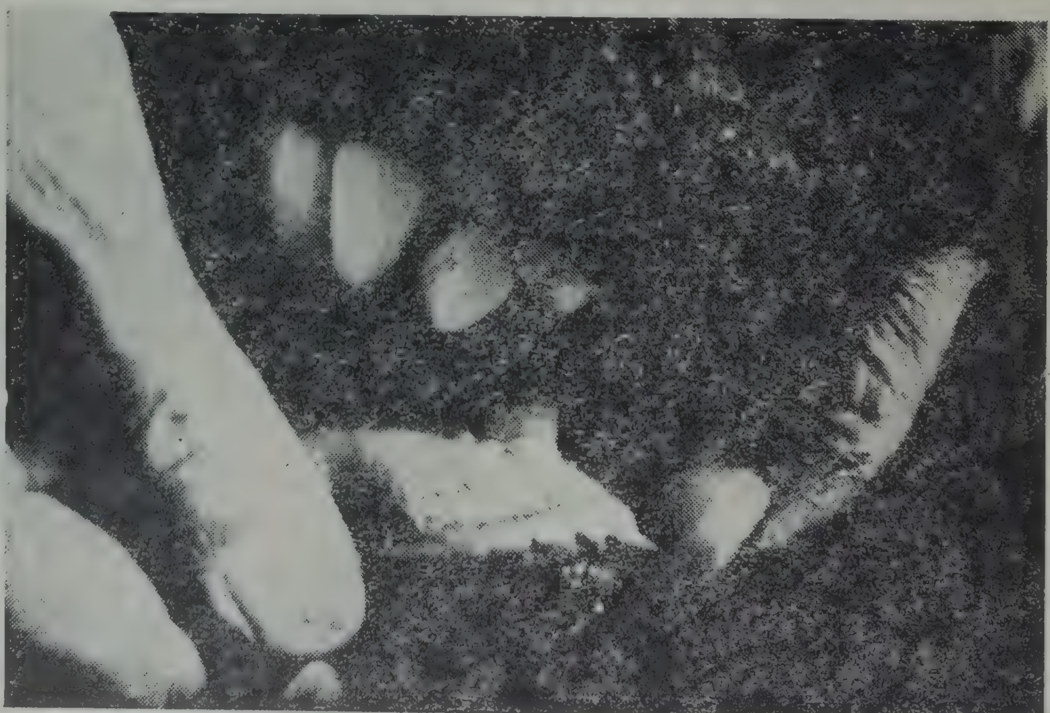


Fig.3. Secondary lesions of foot-and-mouth disease infection on lower lip

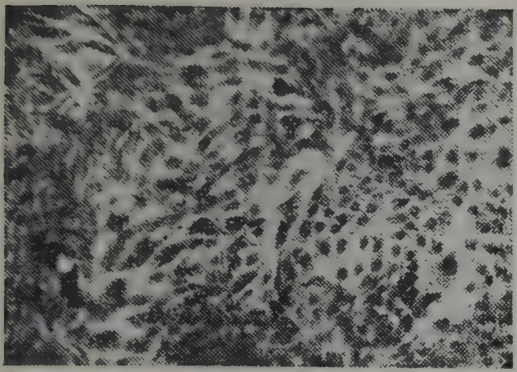


Fig. 4. Living kidney cells (monolayer) ready to receive foot-and-mouth virus for vaccine production

effect is noticed on the monolayers. The collected virus is inactivated with formaline and is incorporated in the vaccine with buffers and adjuvants. The vaccine produced by this method is quite potent and efficacious to ward off foot-and-mouth disease infection.

Since the present vaccine developed at this Institute is an inactivated product, it will afford immunity of shorter duration, which is true of many of the inactivated viral vaccines. Further researches are being carried out to improve upon the present vaccine as well as to develop cheaper and handy live modified foot-and-moth-disease vaccine for the indigenous cattle.

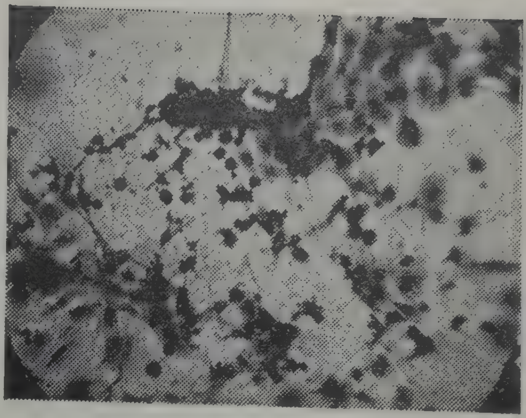


Fig.5. Cytopathogenic changes produced by foot-and-mouth disease virus. The time when virus is collected for vaccine production.

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STEPHANO FILARIASIS

In the buffalo it has not been possible to assess the economic losses due to this condition on national basis.

However, in a small survey conducted at Bareilly during 1969-70, economic implications were tried to be worked out in buffaloes of 6 local dairies. All other things, viz: feeding, management, body weight (within reasonable limits), etc. remaining the same, the affected animals gave approximately 300 ml milk less than the uninfected controls. Although this observation may not lead to positive inferences, it is suggestive that the disease had adverse effect on the productivity of the animals. Buffalo, being the second largest dairy animal of this country, even if 2 per cent of the population is infected out of adult females, the losses would certainly be exorbitant which the country can ill afford.

Dutt (1970b) working at the I.V.R.I. reported the encounter of infective stage and other developmental stage larvae of *S. zaheeri* in a fly similar to the house fly, called *Musca planiceps*. Further work at this place revealed that besides *M. planiceps*, *M. autumnalis* also was found to harbour the infective stage larvae of this parasite (Patnaik and Vinai Kumar, 1972) Laboratory studies on the life cycle of this parasite are still in progress.

Studies on the treatment of this disease revealed that systemic organophosphate compounds were very effective against this disease (Patnaik, 1965; Srivastava & Malviya, 1968; and Patnaik 1969). They obtained remarkable success with Neguvon, a product of M/s Bayers Agrochem, Liverkuseen, W. Germany. In a rough estimate, the cost of treatment of humpsore cases works out to Rs. 1·05 per animal employing 6 per cent Neguvon ointment in vaseline while in the buffalo it would cost only 38 paise per animal for full course of treatment with Neguvon. But due to certain limitations this drug is no more imported into this country. It has, therefore, become necessary to work-out an alternative remedial measure against this disease with medicines manufactured within the country. This is one of the main objectives of the coordinated research project.

Treatment trials against this disease with a few organophosphates used in agricultural pest control operations which are being manufactured within the country have been made. The result of initial trials with organophosphate insecticides were quite promising. The helminthologists at the three centres are actively engaged to work out an efficient and cheap curative agent against this disease. Patnaik, M.M. (1971) reported encouraging results in humpsore cases in exotic animals of Orissa with 'Supona' while formulations employing Malathion and Sumithion are also being tried in earsore cases at the I.V.R.I. (Patnaik, 1971).

Beating the Drought

EMERGENCY FOOD PRODUCTION DRIVE

INSUFFICIENT rainfall and prolonged dry spell in a large part of the country followed by floods in some areas during the present kharif season has created a possibility for a reduction in the production of kharif crops. This likely shortage in kharif production has to be made up by undertaking a massive rabi summer programme, particularly in the important food crops. The important crops in which intensive efforts could result in the desired increase in the production are wheat, rabi jowar, gram and summer rice. The Union Ministry of Agriculture has formulated a massive rabi production programme to cover the shortage anticipated in the present kharif. The above production programmes envisage the following :—

	Area proposed to be brought under (in million hectares)	*Anticipated additional production (in million tonnes)*
Wheat	23	8.8
Summer Rice	3	4.5
Rabi Jowar	0.5*	0.5
Gram	4	2.0

The additional targets aimed at are estimated at 15.80 million tonnes. The Department of Agriculture has worked out a detailed project to achieve the above level of production during the forthcoming rabi summer season and has worked out the requirements of seeds, fertilizers, insecticides, pesticides and credit. A programme for building up the irrigation potential has also been drawn up.

A substantial rise in production during 1972-73 has to be achieved with a reduced availability of inputs, particularly fertilizers. It is felt, that in addition to the crops proposed by the Union Department of Agriculture, the following crops should also be taken up under the rabi production drive, in order to produce more calories and fats.

Barley
Potato
Ragi
Rabi groundnut
Rape and mustard

INPUTS AVAILABILITY

FERTILIZERS

The availability of inputs during the current year has been estimated to be less than that of last year. Efforts are being made to procure additional supply which could be used during this year for top-dressing. Split application would help to overcome any initial inadequacy.

WATER

It is estimated that out of a total quantity of 370 million hectares of water received as annual rainfall over the Indian sub-continent, taking 110 cm as the average rainfall, a major part of it, 170 million hectares goes as runoff. 120 million hectares of water is lost as evaporation and 80 million hectares of water gets into the soil. The water that we thus receive, if we utilize fully is quite sufficient for our agricultural needs in the country. During the karif season rainfall is supplemented by light irrigation; in rabi season, however, it is the stored water in the reservoirs and the water which flows from the stream that is made use of. During this period ground water potential can be tapped considerably. It is difficult to estimate separately the surface water and the ground water that is actually being used in different states. However, assuming that at least half of the stored surface water will be available after the usual losses in the reservoirs, the net available water if properly and effectively managed would cover a much larger area for irrigation than what is being covered at present.

PESTICIDES

Pesticides like carbaryl, endosulfan, monocrotophos and aldicarb and fungicides like Benlate, PCNB and others are not manufactured in the country and are being imported. Further, some of the essential raw materials (amines and metallics like mercury, copper, nickel, etc.) required for formulation of pesticides within the country are also imported. In view of the above, it is very necessary to utilize this input judiciously and effectively.

Importance of attention to the qualitative aspects of input use so as to maximise production per unit of input

Fertilizers

When and how fertilizer is applied affects yield response. The form and rate of fertilizer used also influence when and how it should be applied. By proper placement and timeliness of application, the yield response to a given quantity of plant food can be increased with an increase in profits.

It has been noted that in case of drought at the flowering stage of rice crop a 20% increase in yield can be obtained by foliar spray of 3% urea, 2% phosphate and 0.5 zinc and manganese sulphate and 0.5 ammonium molybdate. Full yield potential of the high-yielding strains are not obtained in soils which are not fertilised in a balanced way with requisite P and K and which are deficient in zinc. Application of adequate quantities of P and K as recommended would ensure a better return of yield per unit of N applied. Prophylactic application of 10 kg per hectare of zinc-sulphate has increased yields appreciably. The increases have been noted to be as high as 8 qintals per hectare. It has also been noted that the mode of application of fertilizers is very important in maximising returns from a unit of fertilizers applied. Drilling of fertilizers has given better returns than broadcast application. Split application of the fertilizers, particularly, nitrogenous fertilizers and foliar spray have proved to be very useful in increasing the net return per unit of fertilizer applied.

In case of phosphatic fertilizers, it has been noticed that if proper application of phosphorus is made according to the placing of wheat and root habits of varieties, there will be a great saving. Placement of P for Kalyansona under close spacing is 1½ times as efficient as broadcasting under wider spacing. Placement of P under closer spacing of Hira is about 8 times as efficient as placement of P for the same variety under wider spacing and 2½ times as efficient as broadcasting under wider spacing. The above data indicate the feasibility of obtaining higher returns per unit of fertilizer applied in case available information is transfered to the field.

Whatever has been said of fertilizers has proved to be equally applicable in case of water also. Water management studies taken up for the different rabi crops have indicated that nearly 30 to 40 per cent of the available water could be saved if better proven procedures were accepted by the farming community. Recent researches at the IARI have indicated that judicious irrigation of wheat crop with major quantity of water to the field capacity level in the root zone reduces the total quantity of water required for maximising wheat yield from 40 cm to 25 cm of water. Conveyance losses through the *kutcha* channels alone work out to about 25 per cent of irrigation water.

Irrigating the crops at the critical levels when water is required by the crop very badly like the crown root initiation stage in wheat, stolon formation and tuberization in potato, pre-sowing irrigation and another after 3 to 4 weeks in case of mustard and gram have proved to be very useful in obtaining the maximum response from the water supplied to the plant. It has also been noted that as low as 90 cm of water will be sufficient for optimum yield of rice where irrigation is given when the surface soil just shows little cracking. Today about 150 to 200 cm of water is being used for 100 day crop in all the states. The saving to the tune of 40 per cent of irrigation water can be easily made in all the rice growing areas, if modern agronomy is introduced into the cultivators' fields.

Recent Scientific findings relating to an improvement in the efficiency of input use.

STRATEGY : WHEAT

Additional Area Under Wheat

There are possibilities of bringing more area under wheat. These are stated below:

Growing wheat as a companion crop by interplanting it with sugarcane in autumn (October) sowing in North-Indian plains.

Inter-cropping wheat with potato. This practice obtains in some parts of U.P. and could be extended to many other areas.

Growing wheat on spare land available with the tea estates in Assam and West Bengal. Extensive lands not planted to tea bushes, are allowed to remain idle in many of the tea estates because of some ban which was imposed by the Government on the estates according to which lands not growing tea but used for raising cereal crops would be given to the cultivators. The result has been that all the land is now lying idle. If there is such a ban it should be removed immediately and the tea estates advised to grow wheat without fear of losing the land.

Growing wheat as an alternative to *Boro* paddy in West Bengal and Assam where the land becomes available by the end of October. *Boro* paddy, when sown in the early or middle part of winter season, remains for almost six months in the field because of the slow growth and development of the crop during the cold season. Under these conditions wheat would be a better alternative because of its suitability to the cold season and its water requirements being much less as compared to paddy. In the interest of increased foodgrains production wheat should be given priority over Boro paddy because with the water that would be needed for one hectare of paddy, wheat can be grown in five hectares. Boro or summer paddy may, however, be grown more profitably when land becomes available for sowing after December. Therefore area between wheat and Boro and summer paddy should be properly allocated to ensure maximum yields from these areas.

Forest Department leases land (ready for afforestation) in some of the northern districts of M.P. having considerable Terai land such as Lakhimpur

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Kheri, Pilibhit and Nainital. The lease is often given late in the rabi season, and after the rabi crops have been harvested the land is used for afforstation. If the lease is given in good time to enable the farmers to prepare the land properly for growing wheat, substantial production from such areas can be ensured.

It is expected that substantial acreage normally utilized for growing upland paddy (Kwari dhan) in Eastern U.P. and Bihar may have remained unsown due to long spell of drought. This area can profitably be brought under wheat (K. 65 or K. 68) or barley.

RICE

Current Season Crop. Unless the growing conditions in the coming months continue to be bad, production in assured irrigated areas is likely to be above normal, although the shortfall in production from upland areas would be very great. Good management practices that came to be adopted as a result of drought are :—

Planting the seedlings rather shallow (deep transplantation occurs when transplantation is done with excess water), and (b) leaving a thin film of water during tillering period—both of which promote heavy tillering. Farmers who have been able to plant rice in July are expected to secure good yields. Good management practices that came about to be practised in Andhra Pradesh as a result of drought situation have been widely publicised through radio, recommending their adoption even in years when water shortage is not serious.

Some production-based ameliorative measures could be considered for the current season :

Planted Fields with Good Water Supply. Increased use of fertilizers should be recommended. It must be recognized that water is only one of the inputs and where this is assured, all other inputs should be maximised.

Planted Fields with Uncertain Water Supply. Farmers should be recommended to delay nitrogen application, but irrigate even by rotation so as to conserve the available water and protect the crop until more favourable conditions prevail. Nitrogenous fertilizer applied even 30 days after planting is likely to give good results. Further, losses of added nitrogen could occur if the fields were exposed to the risk of drying.

Fields Ready to be Planted. Basal nitrogen application should be completely skipped. Phosphatic and potassic fertilizers could be applied. Farmers should be recommended to apply 50 per cent of the programmed dose of nitrogen, 15 to 20 days after planting when the water situation might improve. This is also aimed at minimising the risks of nitrogen losses.

Upland Seedbeds. Plantings might be delayed even if the seedlings are up to 40-50 days old. When the source of irrigation is assured, these should be planted. Even then, if the situation does not improve, a re-sowing of nursery could be taken up with early maturing varieties like *Cauvery*, *Pusa* 2-21, *Tella Hamsa*, *Kanchi*, etc. This practice would not be relevant for northern states where temperature tends to be low during the months of November-December.

Low Land Seedbeds. If there is no likelihood of planting the seedlings before they are 40 days old, it is better to re-sow the nursery. In all such situations, only early varieties as indicated under item 4 should be sown.

Administrative steps which are likely to increase production are :—

Water Conservation Measures. Such as turn duty on irrigation, closing of the sluices of the tanks at night, and localising the area lor planting in order to minimise conveyance losses—could be considered.

Stepping up Other Inputs. Diversion of fertilizers from areas uncertain of production to the areas with assured irrigation facilities may be considered.

A sizable area under rice is located in the northeast monsoon zone covering Tamil Nadu and Southern Andhra Pradesh. In these locations, the programes of high-yielding varieties should be intensified. It might be recalled that a sudden increase in the area under IR 8 in northern districts of Tamil Nadu occurred following the receipt of late rains during the kharif season in the year 1969.

Southern Andhra Pradesh. Nellore, Prakasam and Chittor districts rely exclusively on north-east monsoon rains. High-yielding varieties of rice have not made any major impact in this area due to strong preference for *Molakokkulu* grain type and lack of organized markets for the procurement of high-yielding variety grains. Further, *Molakulukkulu* is a late season variety and is exposed to water shortage after flowering, apart from its high susceptibility to blast disease. The Department of Agriculture, Andhra Pradesh, is mounting a big programme aimed at 60 per cent coverage with high-yielding varieties during late kharif season. Varieties to be popularised are IR.8, *Jaya*, IR.20 *Vijaya*, IET 1 :91 and *Cauvery*.

Northern District of Tamil Nadu. Considerable area has already been covered with high-yielding varieties. Possibilities for extension of area and complete elimination of tall varieties such as TKM 6 and Co 29 could be considered and hopefully accomplished. It is well-recognized that Jaya and IET 1991 would give definitely more yields than IR.8 and IR.20, presently popular in this area. Efforts should be made to bring additional area under Jaya and IET 1991. In location where *Swarnavari* crop is grown, subject to the availability of water, an additional short-duration crop (September-January) with *Cauvery*, *Kanchi* and *Pusa* 2-21 should be considered in advance of the rugular *navarai* season.

(3) *Thanjavur Delta—Kuruvai* season has programmed with the more productive variety *Karuna* in 2 out of 5 lakh of acres. Since *Karuna* is known to give higher yield than IET 27, increased production is anticipated from the current *kuruvai* season.

During *thaladi* season, main programme is with *Mahsuri* (Ponni). It is desirable to consider programmes with Vijaya Jaya and 1136, in addition to the programmes with Ponni. The dwarf varieties recommended would stand additional fertilization and would certaintly excel the productions of Ponni.

Rabi Crop

The coverage with dwarf varieties—IR.8 and Jaya—has been phenomenal in the boro season of West Bengal and dalua season of Andhra Pradesh. The programmes of rabi 1973 would, therefore, be just intensive with no major qualitative changes.

West Bengal. The area under boro season has been progressively increasing. Additional supply of credit for sinking of shallow tube wells would make it possible to further increase boro rice areas in West Bengal. Additional area can be brought under more productive and more acceptable varieties like Jaya and IET 1991, where land becomes available for sowing after December.

Orissa. Areas to be concentrated are Cuttack, Puri, Ganjam and Sambalpur districts. While considerable progress has been accomplished in Sambalpur with the spread of dwarf varieties, programmes in other districts need to be greatly vitalised. The varieties to be emphasized are Jaya, IET 1991 and Ratna. Sowings should be organised between November 15 and December 15, and plantings before the second week of January in order to tide over the probable difficulties with irrigation water during the month of April. The rabi crop might be exposed to stem borer damage during tillering period. Traditional insecticides such as Endrin and Parathion would be adequate to control the pest. Since the state is passing through critical times both due to drought and cyclone, arrangements for seed would have to be made from other areas as expeditiously as possible.

Andhra Pradesh. Major area is in East and West Godavari, Krishna and Guntur districts and relatively less in the Telangana region and Srikakulam, Nellore and Kurnool districts. In addition to the regular crop of rabi (between December and April), a dry season crop (*Kathera*) is planted in Telangana region utilising wells for irrigation.

Traditional practices of rabi planting in coastal Andhra Pradesh (East Godavari, West Godavari Krishna and Guntur districts) is during the month of February. Canal waters are available for irrigation between November and February when they are not utilised for rice, but for a pulse crop which needs far less irrigation. The practice of late planting in rabi came to stay since traditional varieties were susceptible to blast. Late planting is exposed to the risk of severe stem-borer damage which comes about at white ear stage and which could be easily controlled. Further, late planted crop is exposed to the risk of water shortage close to maturity. Planting rabi rice as late as February leads to an inevitable choice of a very early maturing variety (like Co 20) with low yield potential. In West Godavari district, with the availability of high-yielding varieties, plantings of rabi crop have been progressively advanced with benefit. Dwarf rice varieties now available are moderately tolerant to blast disease and could easily be protected from stem borer at dead heart stage. It is, therefore, recommended that all rabi programme of Andhra Pradesh should deal with early planted rabi crop. Suggested varieties for rabi crash programme of Andhra Pradesh are Jaya, IET 1991 and *Ratna* all over the state and in addition *Tella Hamsa* in Telangana region.

The Government of Andhra Pradesh put up a centrally sponsored scheme for crash production of rabi rice. With the extra support requested from the Government of India, this programme is expected to be very successful.

Tamil Nadu. Navarai season crop of North Arcot, South Arcot and Chingleput districts is mostly planted with IR.8, since IR.20 does not perform so well during the season. There were even instances when a planted Navarai crop of IR.20 did not mature. In situations like this, Jaya and IET 1991 should be popularised since these are earlier to mature than IR.8, and are also more productive.

Summer Crop

Only two states—Assam and Bihar—have sizable area under summer crop. Provision of extra lift irrigation facilities in Assam and utilization of tubewells (apart from Kosi project area where flow irrigation is available) in Bihar would increase production of summer crop. Varieties suggested for the season are Pusa 2-21, Sabarmati, Cauvery and Kanchi. Arrangements would have to be made for procurement of seeds from other states well in advance.

BARLEY

Role of Barley in the Present Strategy

Barley can profitably replace low-yielding wheat not only under rainfed and saline-alkali soil conditions, but also under conditions of limited irrigation and fertilizer application. It has been found that where only one or two irrigations are available and no more than 30 kg/ha of fertilizer can be applied, barley would be a more profitable crop to cultivate than wheat. There are vast alkaline and saline lands where virtually nothing is grown at present and where barley can give economic returns if cultivated widely under recommended practices. Thus, additional areas can be brought under barley cultivation without affecting any of the other crops.

Regions of Barley Cultivation. Barley is grown as a major rabi cereal in Uttar Pradesh, Rajasthan, Bihar, Haryana and Himachal Pradesh. It is also grown to a smaller scale in Madhya Pradesh and Punjab.

Suggested Areas for 1972-73 Rabi Programme

Some of the most important barley growing districts have been listed where rabi campaign for 1972-73 may be taken up. In these districts barley is grown in about 1.4 million hectares. Additional areas or districts can be selected by different states depending upon the availability of resources and their relative importance.

State	*Region and districts*
Uttar Pradesh	Eastern U.P.—Jaunpur, Ghazipur, Varanasi, Allahabad, Azamgarh, Mirzapur, Partapgarh
	Central U.P.—Unao, Rai Bareilly, Hardoi, Etawah, Kanpur Fatehpur
	Western U.P.—Aligarh, Mathura, Agra
Rajasthan	Alwar, Jaipur, Tonk, Sawaimadhopur, Bhilwara, Udaipur, Sriganganagar
Haryana	Gurgaon

Recommendations based on Research Results

A. *Rainfed area*

(a) *New Varieties*

State	*Varieties recommended*	*Yield potential in q/ha*	*Increase over check q/ha*
Western Uttar Pradesh	Vijaya (K 72/11)	26.2	2.3
	Check		
Eastern Uttar Pradesh and Bihar	Ratna	19.0	2.0
	Check	17.0	
Rajasthan (Central) and Madhya Pradesh	RS 6	18.4	2.5
	Check	15.9	

The new varieties listed above are capable of giving 2 to 2.5 q/ha more yield than varieties under cultivation. About 200 quintals of seed of variety Ratna is available with National Seeds Corporation.

Agronomic Practices. Research results indicate that nearly 3 quintals of additional grain yield was realised by the application of 20 kg N/ha which will be valued at about Rs 200 at the current prices. Based on these results a fertilizer dose of 20 kg N/ha is recommended.

Results obtained during past three years have convincingly shown that placement of fertilizer 10 cm deep would be the most effective method of fertilizer application under rainfed conditions.

In order to get maximum grain yield under rainfed conditions, barley should be sown during third and fourth week of October.

POTATO

It is well-known that the potato is perhaps the most efficient producer of food per unit area, per unit time. This arises from the fact that bulk of the dry matter produced by this crop is ultimately localised in the valuable end-product (tubers).

With the availability of short-duration varieties such as 'Kufri Chandramukhi' and 'Kufri Alankar', and the flexibility of lifting dates, the potato crop fits in admirably in the multiple relay cropping and mixed cropping systems. In certain areas in the North-Western plains of India as in the Punjab, Haryana and Uttar Pradesh, where winter is comparatively longer, a good crop of wheat of variety S. 308 or RR. 21 can be taken after an early or a seed crop of potatoes. In an experiment at Jullundur (Punjab) per hectare yields of 206 quintals of potatoes followed by 29 quintals of wheat in spring and 32 quintals of maize in kharif were obtained in 1970-71. Autumn crop of potatoes could be followed by potatoes in spring.

Main crop or seed crop of potatoes in Uttar Pradesh and Bihar could be followed by cowpeas, moong, or maize.

In areas where winter is of moderate intensity or duration as in North-Central India, wheat can even be intersown in the main crop of potatoes, to get some additional grains besides potatoes. Alternatively, sugarcane and potatoes can be planted together in autumn to get a fairly good yield of potatoes with little or no detriment to sugarcane. In North-Western parts, sugarcane can be inter-planted in the spring crop of potatoes.

Area. The programme may be undertaken in selected districts near or around big towns and industrial centres where the demand for potatoes is generally high so that transport charges are as low as possible. A tentative list of such places is given below:—

Intensive Potato Development Programme
Tentative list of places where programme could be taken up

State	*Place*
Jammu and Kashmir	Jammu
Punjab	Amritsar, Hoshiarpur, Kapurthala, Ferozepur, Jullundur, Ludhiana, Ropar
Haryana	Shahabad, Yamunanagar, Ambala, Karnal
Uttar Pradesh	Meerut, Lucknow, Farrukhabad, Bulandshahar, Kanpur, Varanasi
Delhi	Delhi
Bihar	Patna, Biharsharif
Rajasthan	Jaipur
Gujarat	Dessa, Kaira
Mahrashtra	Poona, Satara
West Bengal	Hooghly, Burdwan
Assam	Gauhati
Orissa	Cuttack
Andhra Pradesh	Hyderabad

The actual coverage would depend on the availability of reasonably good disease-free seed potatoes, which is the basic factor on which the programme hinges.

(ii) *Seed.* Every year, the Central Potato Research Institute has been supplying 6000 to 7000 quintals of seed to the National Seeds Corporation and the State Departments of Agriculture for the last about 5 years. This seed is under multiplication with these organisations and it is expected that sizeable quantities of certified seed should be available to feed the intensive programme near the big towns. It is understood that 1.8 million quintals of such seed is available in Uttar Pradesh. Similarly, significant amounts of seed may be available with the National Seeds Corporation and State of Maharashtra. Seed is also available with some of the progressive growers who adopt the "Seed Plot Technique", in the Punjab, Haryana and neighbouring areas. High hills in Himachal Pradesh are also expected to produce good crops of seed potatoes for supply to the southern, the eastern and the western States. The seed may not, therefore, be a limiting factor. If necessary, the large-size tubers could be cut and used as seed through treatment with dormancy-breaking chemicals.

JOWAR

For purposes of rabi, the following broad areas may be considered.

(i) *Late Kharif*

The Maghi areas in the district of Khammam, Warangal and Karimnagar and Nandyal valley of Kurnool District in Andhra Pradesh and the Surat District of Gujarat State where the plantings commence in late August-early September constitute the late kharif of mid-season tract. This area is wholly rainfed.

The late kharif (Maghi) areas should be planted with early maturing (CSHI, CSH 2, CSH 3, PSH-2) hybrids as soon as the monsoon breaks.

Traditional rabi

Traditional. Traditional rabi jowar area is predominantly concentrated in the Deccan plateau covering the states of Maharashtra, Mysore and Andhra Pradesh. Rabi jowar constitutes nearly one-third of the total jowar area in the country. Since the crop is grown in the winter (mid-September—mid-October plantings) and matures slowly in clear weather, rabi jowars have a premium in the market and are always priced higher than kharif jowars. The traditional rabi jowars are almost wholly rainfed and come up with the residual moisture stored in these black cotton soil areas.

As a rule planting of traditional rabi jowars should be advanced by a month. Plantings should commence in early September in Sholapur-Bijapur belt and early to mid-September in parts of Andhra Pradesh and Mysore. This would enable application of adequate quantities of fertilizers at planting and results in establishment of satisfactory crop stands. Besides, some rain during early crop growth period could be expected which would be beneficial. Such plantings enable the crop to mature before the soil profile gets depleted of moisture. Since seed may be a limitation with hybrids, traditional varieties could be used. M 35-1, CSH-1 and CSH-2 could all be used.

If plantings are delayed or if September rains are also inadequate resulting in early moisture stress, extremely early hybrids like CSH-2 and CSH-3 will give reasonable yields where the late locals are apt to fail. Depending upon the future rainfall pattern, these varieties could be capitalised under extreme stress.

Fertilization in rabi should all be basal and should give 60 kg P_2O_5 and 60-80 kg N/ha.

Shoot fly control may be achieved by applying one of the following treatments: (a) seed treatment with carbofuran 5 gm (A.I.) per 100 gm of seeds or (b) Phorate(Thimet 10per cent granules in seed furrow at 1.5 gm/metre row or Thiodemeten 5per cent granules in seed furrow at 3.0 gm/metre row or adapting a slightly higher seed rate and thinning affected plants three weeks after sowing.

Sugary disease of ears and midge if occurring may be controlled by 0.2 per cent Ziram or Thiram sprays alone or in combination with carbaryl (50 per cent WP) 3 kg in 500-600 litres of water per hectare for midge control at 50% flowering.

Irrigated Summer Season

The irrigated summer season (January–February plantings) is also clubbed under rabi for statistical purposes of the seasonal distribution of areas. This season is more analogous to the short duration kharif and is predominantly distributed in Tamil Nadu.

While rainfed rabi production is dependent on preceding rains, prospects for additional production during irrigated summer may be considered assured. It is possible to plan for a targeted additional production and every additional acre could yield 1-2 tons of grain. It is, therefore, suggested that this should be attempted in concentrated areas in Andhra Pradesh (Nagarjunasagar, Tungabadhra, Krishna and Godavari deltas), Mysore (Tangabhadra and Bhadra Project areas) and Tamil Nadu (Wells).

The early duration CSH-1, PSH-2 and Swarna could be grown in pure crops under the projects. The paddy fallows offer potential scope. It is necessary to provide price support here since the local people are not accustomed to consume jowar. jowar grains from these areas could be procured and taken to jowar consuming areas.

The fertilizer and insect control schedules remain the same as described for the traditional rabi crop and 4-6 irrigations will be needed during crop growth. Plantings should be done from January 14th onwards to February first week.

Mixed Cropping. There is a substantial area under irrigated groundnut in the states of Andhra Pradesh, Mysore and Madras. Groundnut plantings commence during December and extend upto January-February. All areas where groundnut plantings commence from January onwards could have a component of the short-duration varieties or hybrids viz., Swarna or CSH-1 or CSH-2 in the proportion of one row of jowar to 6-8 rows of groundnut. Seed rate of groundnut should not be reduced. The basal dressing of fertilizers should be common to both crops but jowar alone may get side dressed at 30-40 days to give additional 30-40 kg N/ha. This would add a substantial amount of food and fodder without any major loss in groundnut production.

Prospects for any targetted additional production are greater during the irrigated summer in view of the time available for planning and also in view of the assured irrigation. There is apparently no risk involved.

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Editor's page

Agricultural Scientists : The New Revolutionaries

CONVENTIONAL ideas, hitherto accepted mores, demand a second look in developing countries: particularly in countries like India with enormous problems of teeming population, poverty, hunger, production bottlenecks, unequal distribution of wealth, regional disparities and so on.

What was true of 1870 will not be true of 1970. What is true of America or France will not be true of India. If at a certain period of history, Rousseau the thinker triggered off a revolution, today it is the geneticist or the agronomist who can trigger off an even more relevant revolution—a revolution to end poverty. If 'liberty, equality, fraternity' was the *mantra* in a less enlightened age, a technique to produce three crops where only one grew previously becomes a more potent or more revolutionary theme because hunger in the context of population explosion has become *the problem* of the underprivileged sections. And so who is the revolutionary, the true intellectual, the true activist? Or let us say the more relevant ones? It is the man skilled or steeped in a discipline, the man with a technique which can produce more food from land which was hitherto inhospitable to crop plants. In other words, feeding millions is the revolutionary task of the day and the man who can carry out the task is the true revolutionary of the day.

In the twenty-fifth year of independence, we feel the need to pontificate on these lines. We may be excused. The compulsive thought behind this is that the agricultural scientists should be conscious of their historic role in the current context of the development of India. Only a resurgent agriculture which, in all its dimensions, will reach out to every village in India, every sector of rural society, can succeed in bringing about a New Deal, conferring a new destiny to the rural masses. For all time, may be in societies like ours, social justice would be inextricably mixed up with a new type of agriculture. As population further explodes, even from two hectares, the land ownership norm would be further pushed down to a few cents per family. But even this little land would have to be made productive enough to sustain the family. This would be the 'Social-justice-chapter' of the Green Revolution.

And hence the unconventional thinking on our part.

And hence our *raison d'etre* for calling the agricultural scientists the new revolutionaries.

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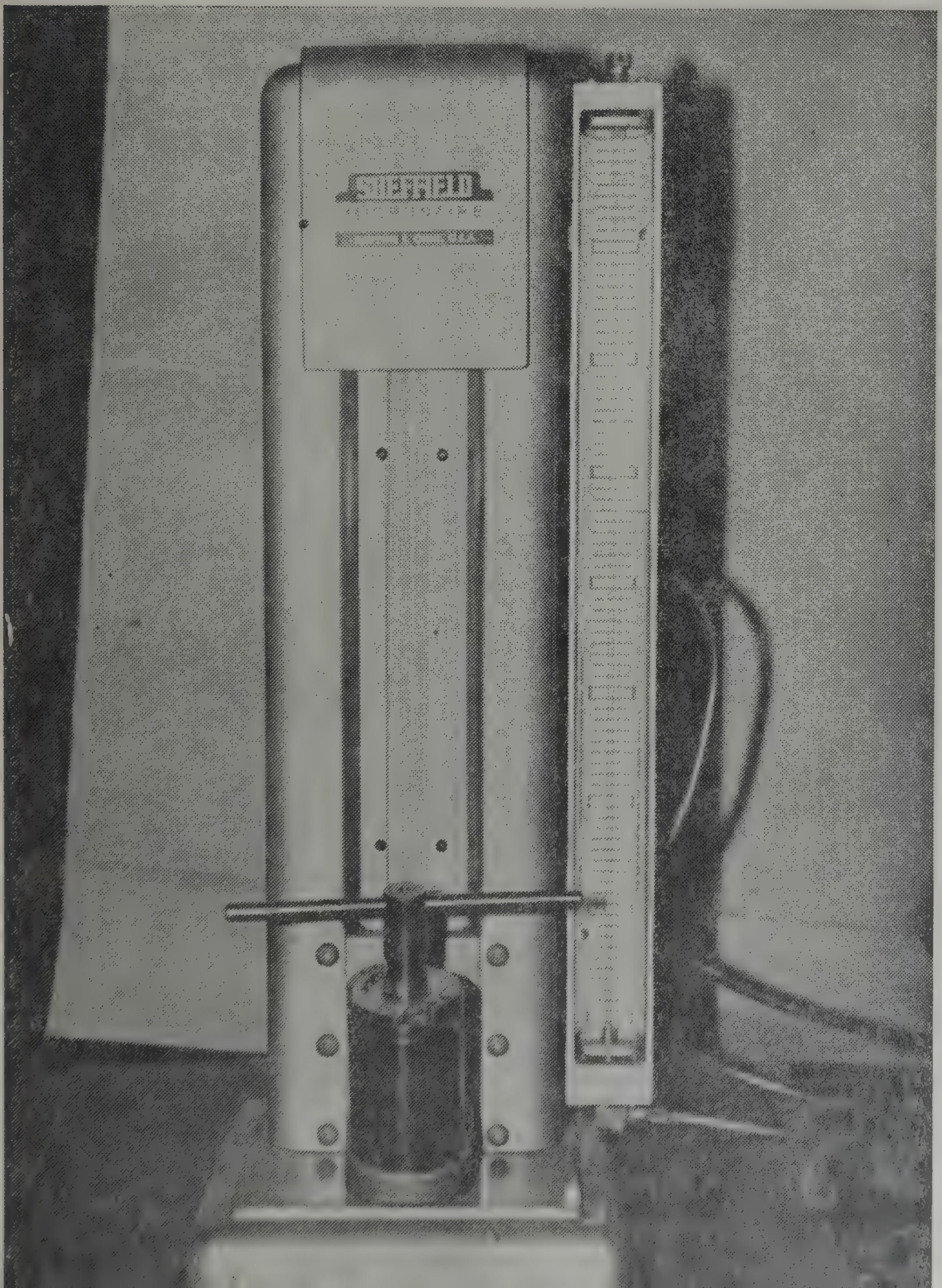
RAPID STRIDES IN COTTON QUALITY IMPROVEMENT

Micronaire

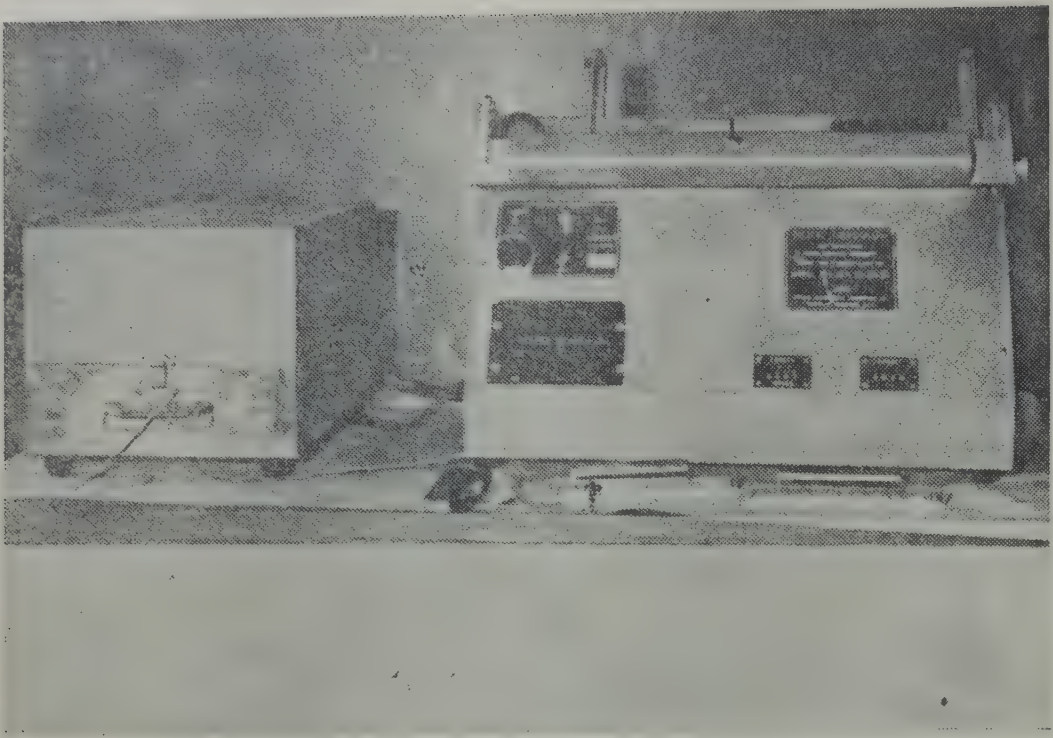


V. SUNDARAM
Director, Cotton Technological Research
Laboratory, Adenwala Road,
Matunga, Bombay

ALONG with food and shelter, clothing is one of the essential requirements of the human being. Amongst the various textile fibres used as raw material for manufactures of cloth, cotton occupies the most important position in view of its comfort characteristics as well as easy availability. India has the largest acreage under cotton amongst the various countries of the world and ranks fourth with regard to cotton production. The cotton textile industry is one of the most important industries in our country in terms of goods produced as well as labour employed. During 1969-70, the total export of cotton yarn and cloth from India was valued at over Rs 140 crores. In view of this, considerable attention is being rightly given to the improvement of quality of cotton produced in our country which is the raw material for our cotton textile industry.

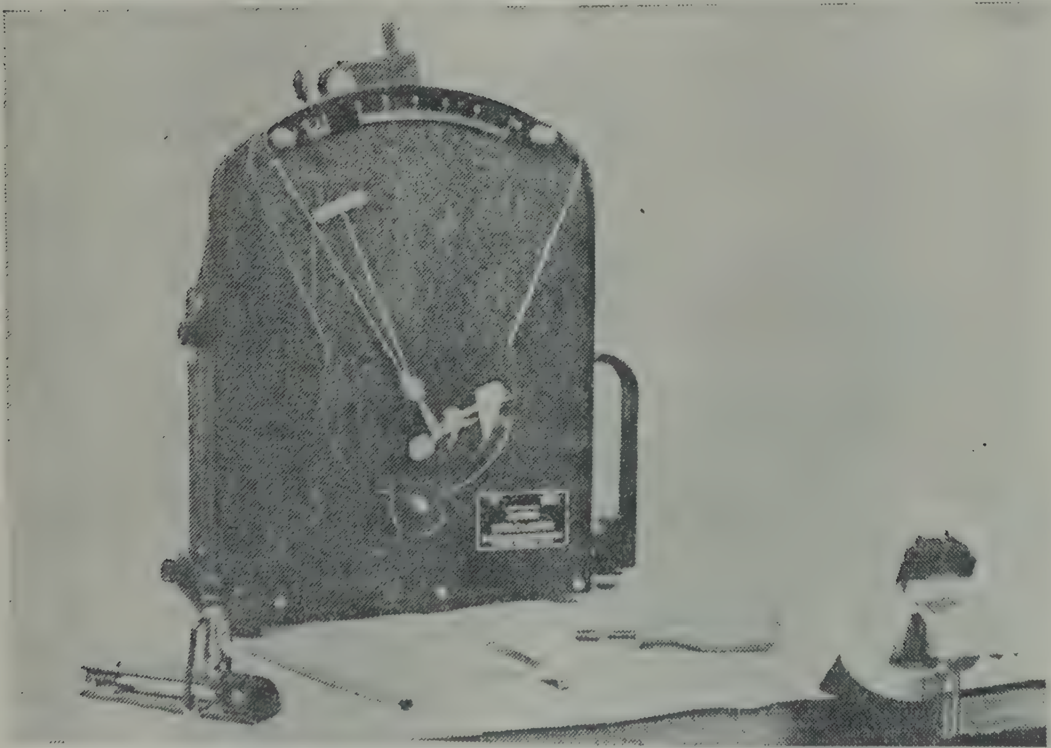
Arduous Research

Research work for cotton improvement is a laborious process and



Digital Fibrograph

Stelometer



it takes many years to evolve a new strain having the desired quality of fibre in combination with economic yield and other characteristics. For this purpose, several thousands of samples have to be tested year after year for various factors, such as yield, quality, resistance to pests and diseases, etc. before a few promising strains can be identified. The Indian Central Cotton Committee (ICCC) established in 1923, for the purpose of research on cotton in India financed several hundred research schemes dealing with various aspects such as breeding, agronomy, physiology, pathology, entomology, etc. One of the earliest actions of the ICCC was the establishment of its Technological Laboratory at Bombay in 1924, in order to assist the cotton breeders in developing strains by providing authoritative valuation of the qualities of the strains and to carry out basic research on the properties and spinning of cotton. Along with other Commodity Committees, the ICCC was abolished with effect from the 1st April, 1966 and the functions of financing and directing research on all agricultural commodities including cotton has been taken over by the Indian Council of Agricultural Research (ICAR).

Detailed investigations were undertaken at the Cotton Technological Research Laboratory (CTRL) on various aspects such as sampling, standardization of testing techniques, the influence of various factors on test results, etc. A procedure for assessment of the spinning performance of cotton in terms of the Highest Standard Count (H.S.C.) spinnable from it was standardised; for this purpose 'full-spinning' tests are carried out using 4.5 kg of the sample and spinning it into three counts of yarn. Further, in order to assess the spinning potential of material even in early stages of breeding, a 'micro-spinning' technique was developed for spinning small quantities (about 100 g) of the sample.

Laboratory

The different sections of the Laboratory have been provided with various instruments and equipment for carrying out work in fulfilment of the main objectives of the CTRL. The Laboratory is the only Institution having a Ginning Section, equipped with various types of roller gins and pre-cleaning machinery. The Spinning Section is provided with an entire range of machinery for processing cotton from Blow Room to Ring-frame. Various instruments such as Balls Sorter, Baer Sorter, Fibrograph, Micronaire, Pressley Tester, Stelometer, Lea Tester, Uster Single Thread Strength Tester, Scott Tester, Uster Evenness Tester, Goodbrand's Cloth Strength Tester, Martindale Abrasion Tester, Crease Recovery Tester, Brabender Moisture Oven, Shirley Moisture

Tester, etc. are available in the Testing Section. Further, special items of sophisticated equipment such as X-ray Unit, Spectrophotometer and Colorimeters, Polarizing and other types of Microscopes, Instron Tensile Tester, etc., are also available at the Laboratory for carrying out research work. Some of these are depicted in photos on these pages.

The Cotton Technological Research Laboratory maintains field units at important cotton breeding centres in the country where preliminary screening of experimental strains is carried out by conducting tests for fibre properties. At present, there are nine stations located at Coimbatore, Bharwar, Nandyal, Nanded, Surat, Indore, Hissar, Ludhiana and Sriganganagar.

Release after Proved Performance

The material from advanced stages of breeding is tested at CTRL for fibre properties and spinning performance by micro-spinning or full-spinning technique. The release of a new strain for cultivation is considered only if the performance of a strain by the full-spinning technique (using 4.5 kg sample) is satisfactory as compared to that of the existing control variety. Further, the Laboratory arranges for conducting tests on the new strain along with the control in mills to convince the industry of the improved quality of the new strain and to ensure that the cultivator gets an appropriate price. Generally, no new strain is released for cultivation unless it is superior to the control variety in yield and/or quality; if it is superior in yield, it should have at least the quality of the control while if it is superior in quality it should have at least the same yield as the control.

Even after a variety is released for cultivation, samples from different stages of propagation are tested each year to ensure that the quality is maintained. The Technological Circulars and Report on the trade varieties of Indian cottons give an idea to the growers, trade and industry of the actual performance of the varieties in cultivation in different regions.

Although considerable progress has been made in cotton production research in the country, since the establishment of the ICCC, the country faced a critical situation when it became independent in 1947. As a result of the partition, the regions covering 2/5th of the total crop, including a large proportion of the long and medium staple production, went over to Pakistan. However, almost all (98%) of the textile mills were situated in the Indian Union territory. As a result, the industry faced severe shortage of quality cotton and substantial quantities of foreign cotton had to be imported.

Production Pattern Changes

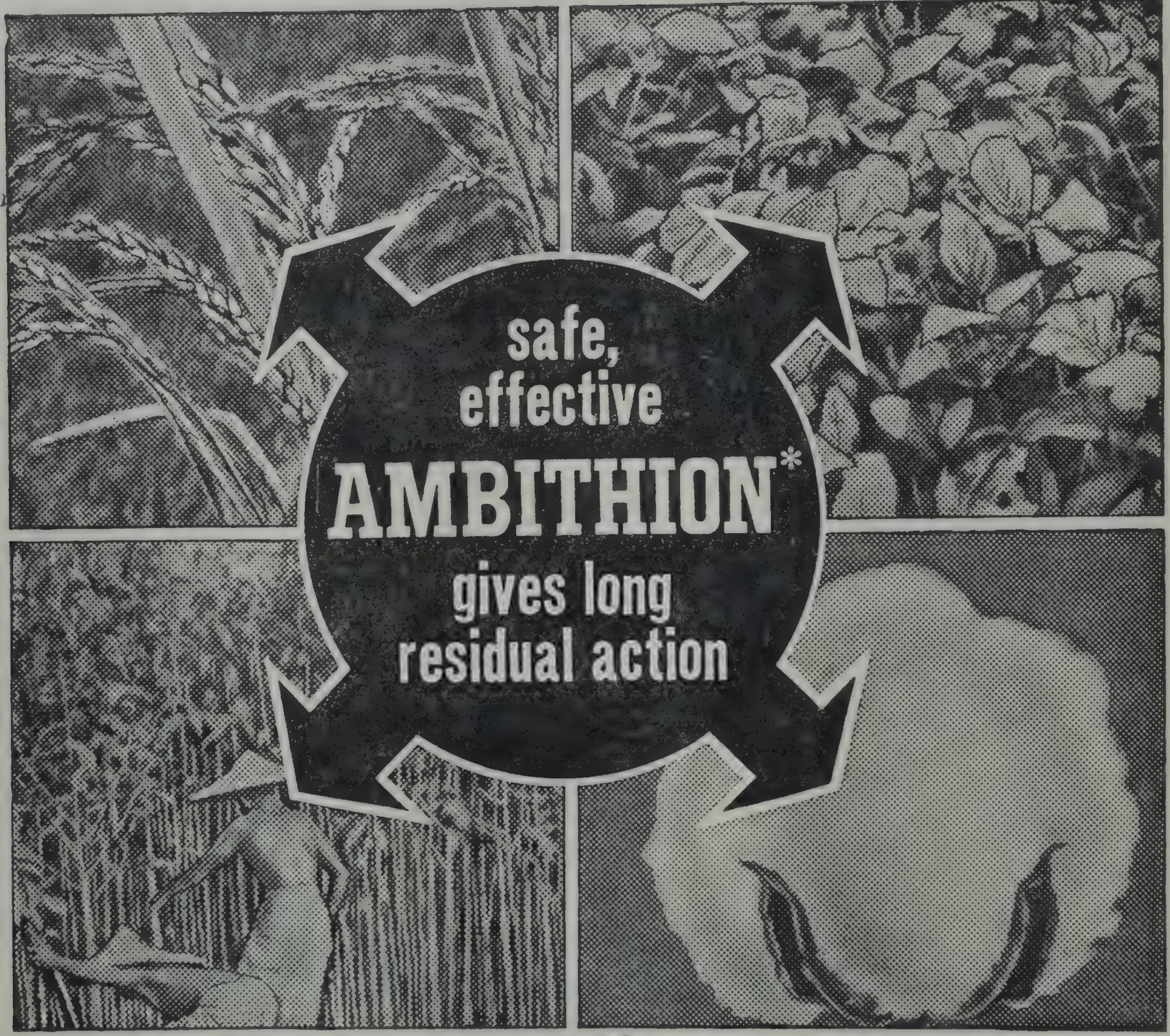
The task of improving cotton production in India was taken up once again vigorously and within a decade, the pattern of production changed entirely. The proportion of varieties with staple length of 22 mm (28/32″) and above increased from about 15% in 1947-48 to 43% in 1956-57, the first year of the Second Five Year Plan and to about 64% in 1965-66, the last year of the Third Five Year Plan. During 1969-70, the proportion of varieties with staple length of 22 mm and above was 75 per cent of the total production. This considerable change in the pattern of production of cotton has been depicted in chart on page 10. Cotton production in the country reached an all time record during 1971-72 and the production was estimated to be of the order of 64 lakh bales. This has been possible mainly because of the release of high quality and high-yielding varieties in recent years.

Further, it may be pointed out that the proportion of imported cottons had decreased from about 11 lakh bales in 1951-52 to about 7.6 lakh bales in 1964-65 in spite of the increase in total consumption of cotton from about 40.7 lakh bales to nearly 63.7 lakh bales during the same period.

Improved Strains

This substantial improvement in production was due to the development and release of a large number of improved strains. Some of the improved types under cultivation at present are 320F, J. 205 and H. 14 in the Rajasthan, Punjab and Haryana States; Narmada (A-51-9), Khandwa-1, Khandwa-2 and Badnawar-1 in Madhya Pradesh; Digvijay, Deviraj (170-Co. 2), Gujarat-67 (I.S.C. 67), Hybrid-4 and V. 797 in Gujarat State; Virnar, Sanjay, Gaorani-22, AK 235, AK 277, L. 147, B. 1007, Deviraj and Laxmi in Maharashtra; Jayadhar, Suyodhar, Laxmi, Deviraj and Hampi in Mysore; Gaorani, Laxmi, Krishna, Nandicum and Adonicum in Andhra Pradesh and M.C.U. 4, M.C.U. 5, Laxmi, K. 7, K. 8 and P.R.S. 72 in Tamil Nadu State. A small quantity of Sea Island Andrews cotton (staple length about 35 mm or 1.3/8 inches) is grown in parts of Andhra Pradesh and Mysore while the superior quality strain Sujata is now under cultivation in the Coimbatore District of Tamil Nadu.

In this connection, it may be noted that after the ICAR took over the entire responsibility of cotton research in the country, an All-India Coordinated Cotton Improvement Project was launched in April, 1967. The approach under this Project is multi-disciplinary so that research can be carried out simultaneously and in a coordinated manner on breeding, technological and agronomical aspects, as well as on control of pests and diseases. The country has been divided into three major zones and multilocation trials are being conducted in each zone. In some cases promising strains from one zone are also tried in other zones. In the past, several years were spent in evolving a new strain at the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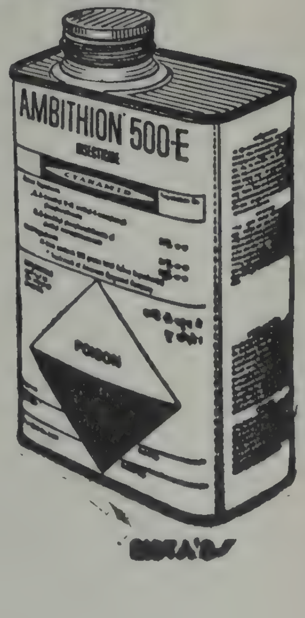
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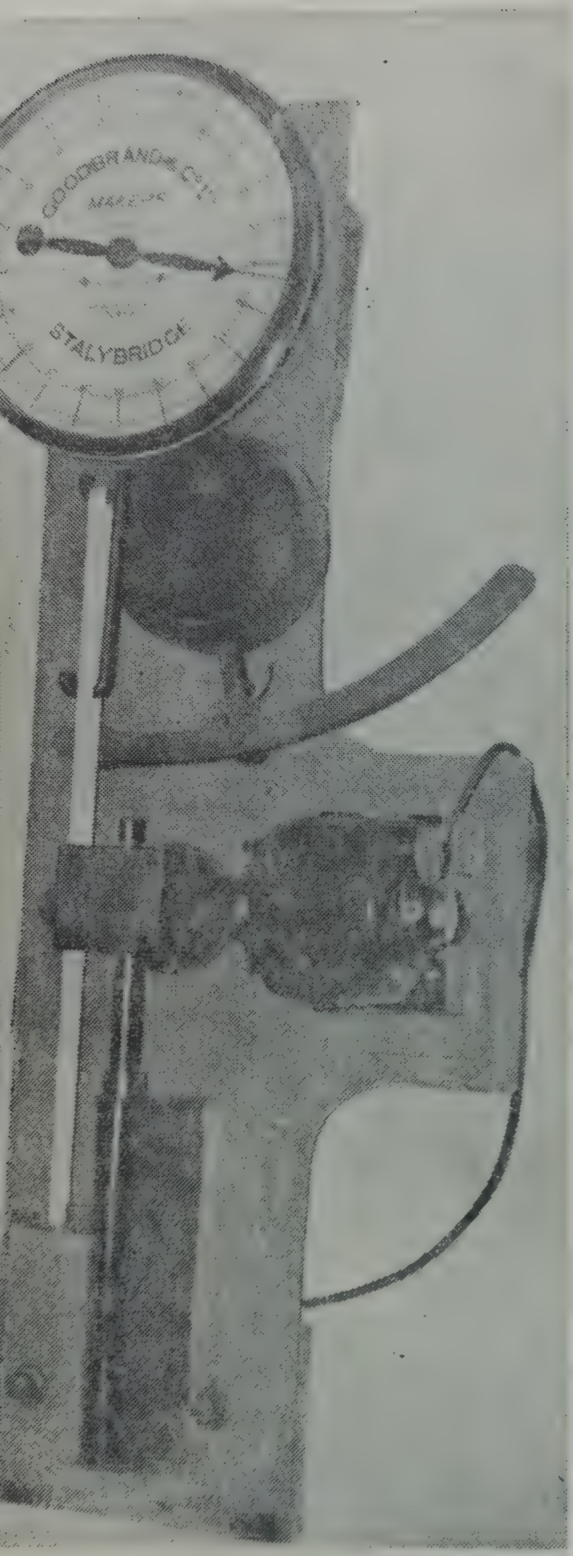
TABLE I. CHARACTERISTICS OF SOME OF THE NEW COTTON VARIETIES

Serial No.	*Variety*	*Kapas yield* (q/ha)	*Ginning* outturn (%)	*Mean fibre* length (mm)	*Fineness*		*Bundle strength* (lb/mgm)	*Highest Standard count* (H.S.C.) *spinnable*
					Micronairs value	*Millitex*		
1	2	3	4	5	6	7	8	9
1	Krishna	18.2	33	25.6	4.6	181	8.9	44s
	P. 216F (Control)	16.5	33	24.0	4.4	173	9.4	42s
2	MCU-5	19.1	34	29.0	3.2	126	8.2	70s
	MCU-1 (Control)	16.8	35	26.0	4.0	156	7.8	43s
3	G. 27	10.7	37	16.0	6.5	257	8.4	—
	231-R (Control)	9.0	38	16.2	6.9	271	6.7	—
4	Khandwa-1	5.7	36	24.6	4.4	172	9.0	43s
	Narmada (Control)	5.4	36	22.7	4.3	167	8.7	34s
5	Sujata	20.5	32	29.0	3.9	154	9.3	100s
	Sea Island Andrews (Control)	9.2	32	32.0	3.6	142	8.2	80s
6	Bharati	6.9	36	25.0	3.6	141	8.5	40s
	K-7 (Control)	3.1	35	24.0	4.6	181	9.2	34s
7	Mahalaxmi (1301-DD)	5.7	36	24.3	3.2	126	7.9	33s
	Laxmi (Control)	4.4	33	24.3	3.8	150	8.0	35s
8	Hybrid-4	30 to 40	36	29.0	4.6	181	7.9	50s
	Gujarat-67 (Control)	6.8	34	31.7	3.9	154	7.8	46s
9	3943	6.3	39	23.3	4.4	173	8.7	31s
	Digvijay (Control)	5.3	38	22.5	3.9	154	8.7	32s
10	Khandwa-2	9.2	36	24.1	4.1	162	8.8	34s
	Maljari (Control)	4.3	36	21.8	5.2	205	7.9	26s
11	MCU-7 (1143-EM)	12.3	33	25.0	4.1	160	7.9	46s
	P 216F (Control)	9.5	33	23.0	3.3	130	7.1	37s
12	K 8 (0078F)	3.2	35	25.4	4.7	186	9.7	37s
	K 7 (Control)	2.7	34	24.3	4.8	189	9.1	34s
13	J. 205	12.3	34	25.3	3.8	151	8.7	34s
	J. 34 (Control)	10.7	35	24.4	4.1	161	8.8	32s
14	R.S. 89	17.6	33	26.4	3.7	146	10.1	48s
	320 F (Control)	14.5	33	24.4	4.6	181	8.9	34s
15	355-E. 6	6.9	32	22.6	5.0	197	10.0	28s
	Nandicum (Control)	5.6	30	21.8	4.6	181	9.9	28s
16	GS. 23	9.7	41	22.8	3.8	149	7.7	36s
	Laxmi (Control)	8.7	32	22.3	3.6	141	8.0	40s
17	Varalaxmi	23.6	33	32.7	3.2	126	8.4	50s
	Hybrid-4 (Control)	18.0	38	29.2	4.0	156	7.0	41s



Lea Strength Tester

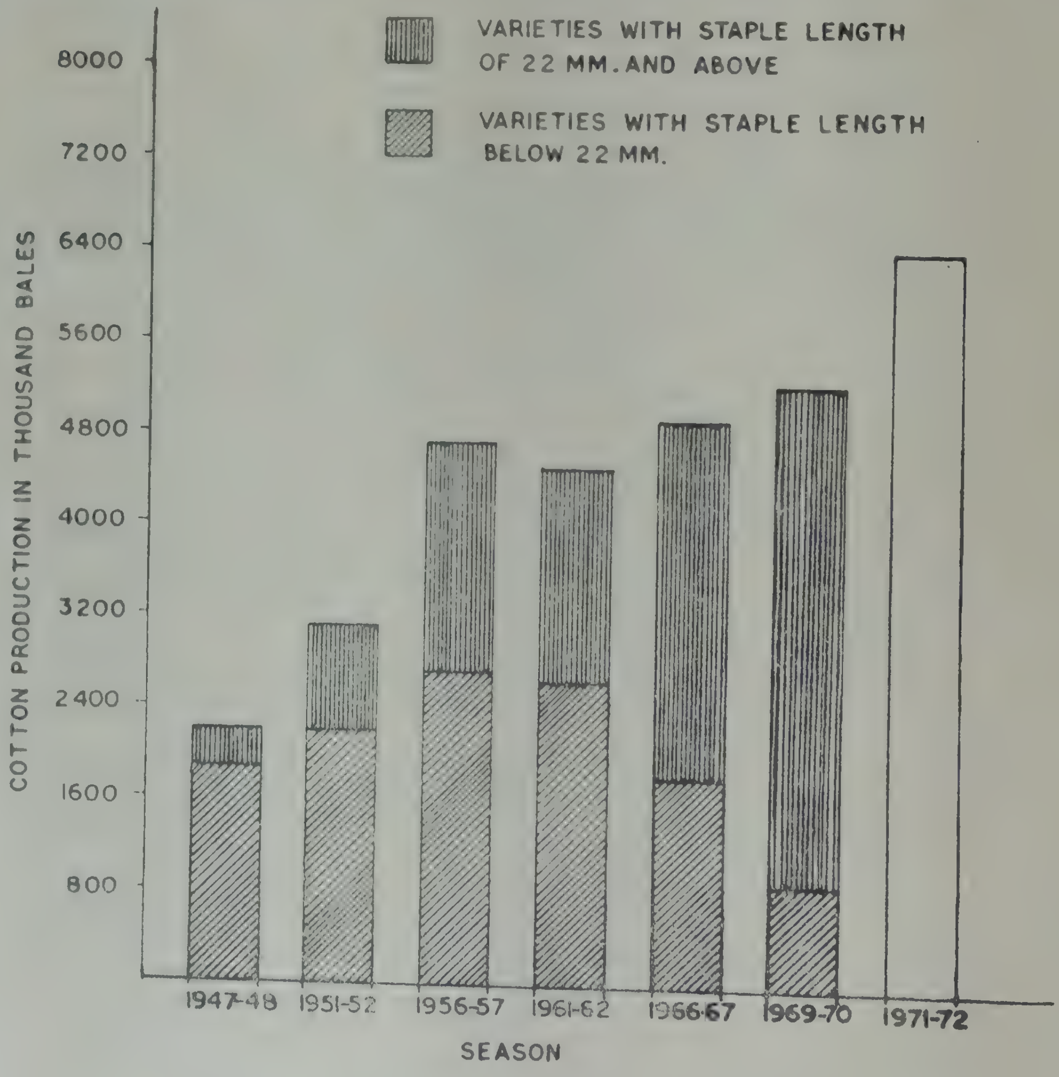
breeding centre, followed by district trials, etc. to evaluate properly the performance of the new strain before its eventual release for large scale cultivation. Under the new Project, the multilocation trials can clearly indicate within the course of two or three seasons, the yield potential and technological characteristics of the new strain and whether the strain has good adaptability. Such an approach has been helpful in making a significant progress in the early location and development of promising strains.

Some of the strains mentioned earlier have been released as a result of the research conducted under the Coordinated Cotton Improvement Project. The comparative performance of some of the new strains released under the Coordinated Project is given in Table I, (Page 9).

Amongst the above strains, Hybrid-4 has been outstanding in view of its high yielding ability, while M.C.U. 5 has been outstanding in respect of quality and adaptability. A significant breakthrough in quality improvement has been achieved by the release of the strain 'Sujata' for cultivation in the Coimbatore tract. This strain selected from Egyptian Karnak material at the IARI Regional Research Station, Coimbatore, compares very well in quality with several strains imported from Egypt and Sudan. This is the first strain capable of spinning 100 counts released in our country for commercial cultivation. Further work for producing still superior quality strains is in progress at various centres. For instance, at Coimbatore, a new strain 'Suvin' obtained by crossing Sujata with Sea Island St. Vincent variety has been developed. This strain has a high staple length (about 38 mm or 1.50 inch) combined with good fibre strength and is capable of being spun into yarn of 120s count and above.

In this connection, it may also be pointed out that with a view to increasing cotton production in rainfed tracts, trials are under way for replacing desi cotton strains with *hirsutums*. It should be noted that *hirsutums* are better in quality than desi strains. As such, replacement of desi cottons will increase not only the total quantity of cotton production but also increase the proportion of better quality cotton in the total production.

With the intensification of research under the Coordinated Cotton Project and with the background of achievement in the cotton quality improvement made in the country during the last 25 years, India can look forward to increased production of quality cottons as well as achieve self-sufficiency in cotton production in the years to come.



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4. The recommendations should be conveyed in simple language. Tables and charts should be kept to the minimum. The significance of the data should be explained in simple, straight prose. Technical language that would go well with a research article should be avoided while writing popular articles for *Indian Farming*. Weights and measures should be in metric system.
5. The length of an article should be restricted to a maximum of 5-6 type pages in double-space (1500 to 2000 words).
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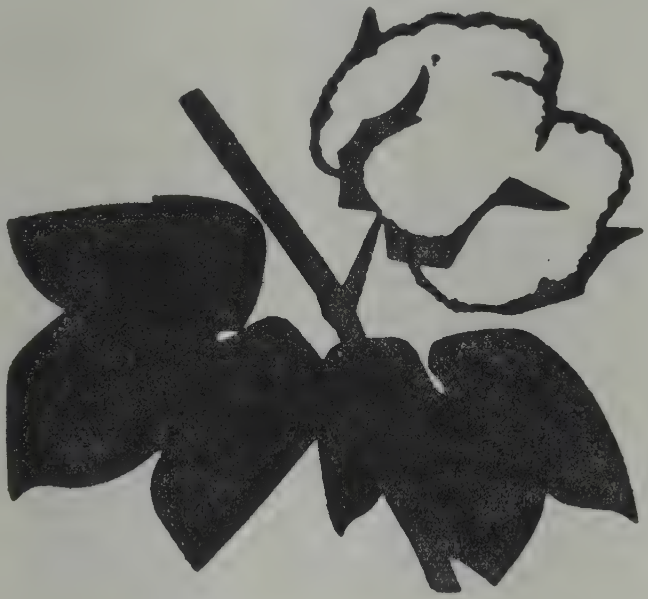

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Broodlac in wirenet basket tied for inoculation

TWENTY-FIVE YEARS OF RESEARCH IN LAC

S.C. SENGUPTA
Director, Indian Lac Research Institute,
Namkum, Ranchi

THE resin is the hardened secretion of the tiny lac insect thriving on certain trees which are consequently called host trees. Though the resin was known from time immemorial, only at the end of the last century the importance of the resin was realised and attention was given for its systematic cultivation and proper utilisation. Over 80 per cent of the world produce of lac is from India. It provides part time occupation and much needed subsidiary income to about 40 lakh cultivators mostly *adivasis* and as such contributes sufficiently to their welfare.

There are two distinct strains of lac insects in India, namely *Kusmi* and *Rangeeni*. The former is mainly available from *kusum* (*Schleichera oleosa*) tree or other hosts with *kusum* brood while the latter from hosts other than *kusum*. Each strain passes

Trained Galwang bush

through two generations in a year and consequently there are four crops per year. The two *Kusmi* crops are each of six months duration and are called *Jethwi* (January-February to June-July) and *Aghani* (June-July to January-February) while in *Rangeeni* crops one is of eight months and the other of four months duration which are called *Baisakhi* (October-November to June-July) and *Katki* (June-July to October-November). Of the total Indian output, nearly 80—90% are obtained from *Rangeeni* crops, the *Baisakhi* being the major commercial crop. The *Kusmi* crops, though produced in smaller quantities, are superior in quality, have greater demands and fetch better price.

Untapped Potentialities

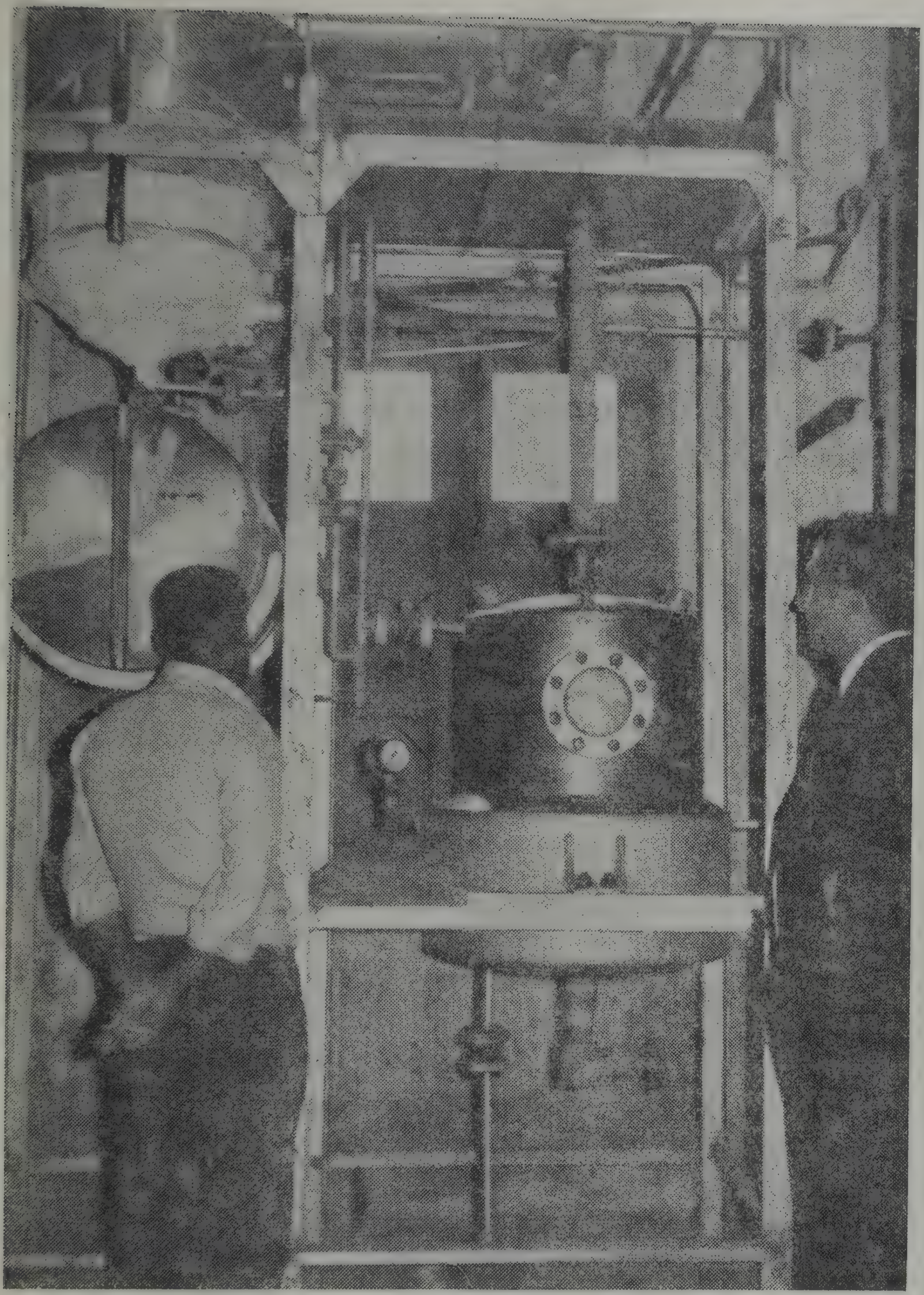
India possesses untapped potentialities for lac production. Limitations in production are, however, posed by the volume of exports. Before the second World War, India had a virtual monopoly in the export of refined lac to the world but after the War, Thailand has emerged as a serious competitor. The cost of production of lac in Thailand is lower than India as the yield per tree there is higher. However, the quality of Thai lac is poor. On the other hand, though lac is the only natural resin par excellence, it started facing stiff competition from synthetics since the last World War. Before the War the biggest outlet for lac was in the gramophone industry which has gradually been replaced by synthetics. Lac has also been ousted from some of its surface coating. Though the greatest advantage of lac over its synthetic rivals is its versatility as it has some of the qualities which are unique in character and which no single synthetic resin so far possesses, there are certain drawbacks from which lac suffers for certain specific applications.

In order to meet the above challenges, the major task ahead in the post-Independence days was to tackle urgently the following main problems in the various Divisions of the Institute: (1) Development of improved cultivation techniques and other measures to reduce the cost of cultivation of lac of improved quality; (2) Working out newer modifications and newer uses of lac for increasing the consumption of lac in this country as well as abroad, and (3) Development of improved techniques for processing of lac, for economic utilisation of by-products of lac and for grading and analysis of lac.

Major Achievements

The major achievements so far obtained during the last 25 years of our Independence on the above lines are briefly enumerated below:

Improved method of lac cultivation. The main host trees under lac cultivation in India are (i) *kusum* (*Schleichera oleosa*), (ii) *palas* (*Butea monosperma*) and *ber* (*Zizyphus mauritiana*). In order to ensure maximum sustained production of lac from season to season in the host trees, a coupe system of cultivation for *Rangeeni* hosts was evolved. The number of coupes in which the hosts will be divided will depend on the species of hosts and their growing habits. *Palas* should be divided into three coupes with equal number of trees in each; two coupes to be utilised for raising the *Baisakhi*-cum-*Katki* crops in alternate years from Oct.-Nov. to Oct.-Nov. of the succeeding year while the third



Wax extraction pilot plant

coupe for the commercial *ari* (immature) crop every year from Oct.-Nov. to April of the succeeding year. *Ber* may be utilised for growing a commercial *ari* crop like the third coupe under *palas*. In the case of the slow growing *kusum* trees, these are divided into four coupes and each is utilised for raising crop once in every two years. The trees thereby get sufficient rest for one and a half years.

Maximum yield of lac can only be obtained if sufficient number of young shoots are made available to the lac larvae for settling after emergence. This objective can only be met by the most important and essential operation of timely pruning of the host trees. The proper time of pruning of *palas* and *ber* trees is about the middle of April while in the case of *kusum* trees the cropping or harvesting operation itself serves as pruning.

Lac crops should be harvested only one week earlier prior to larval emergence to ensure satisfactory emergence of healthy larvae for next generation. This period has been found quite satisfactory for transportation of broodlac from place to place without any detriment to inoculation. To obtain maximum yields from a crop by infecting at proper time without wasting lac larvae it is absolutely necessary to know the dates of emergence. To forecast dates of emergence of lac larvae a scientific system has been developed based on the development of embryos in the ovary of the females by examining under a microscope. It has, however, been found that the temperature and humidity play a very important role in egg laying and coming out of larvae from inside the lac test of the mother. Egg laying practically stops if the temperature falls below 17°C in summer and below 15°C in winter. Hence under the above conditions the emergence normally is delayed for some time.

As a result of systematic investigations, it has been established that *ber* should be exploited for *Katki* (winter) crop and *palas* for the *Baisakhi* (summer) crop where both the species are available.

The important host trees, *palas*, *ber* and *kusum* are slow growing species and require at least 10 to 15 years to become ready for lac cultivation and consequently it is not practicable to have cultivation on plantation basis on these hosts. Hence for intensive cultivation of lac on plantation basis, specially the superior *Kusmi* lac, alternate hosts were searched and *bhalia* (*Moghania macrophylla*) a natural bush, 2.5—3.0 m high, has received considerable attention. It has been found to be suitable alternate host not only for *Kusmi* lac but also for *Rangeeni* lac and already recommended for intensive cultivation of lac specially *Kusmi* lac on plantation basis. However, this host has been found to be unsuitable for *Jethwi* crop as it is unable to sustain large population of the insects during the summer months. On the other

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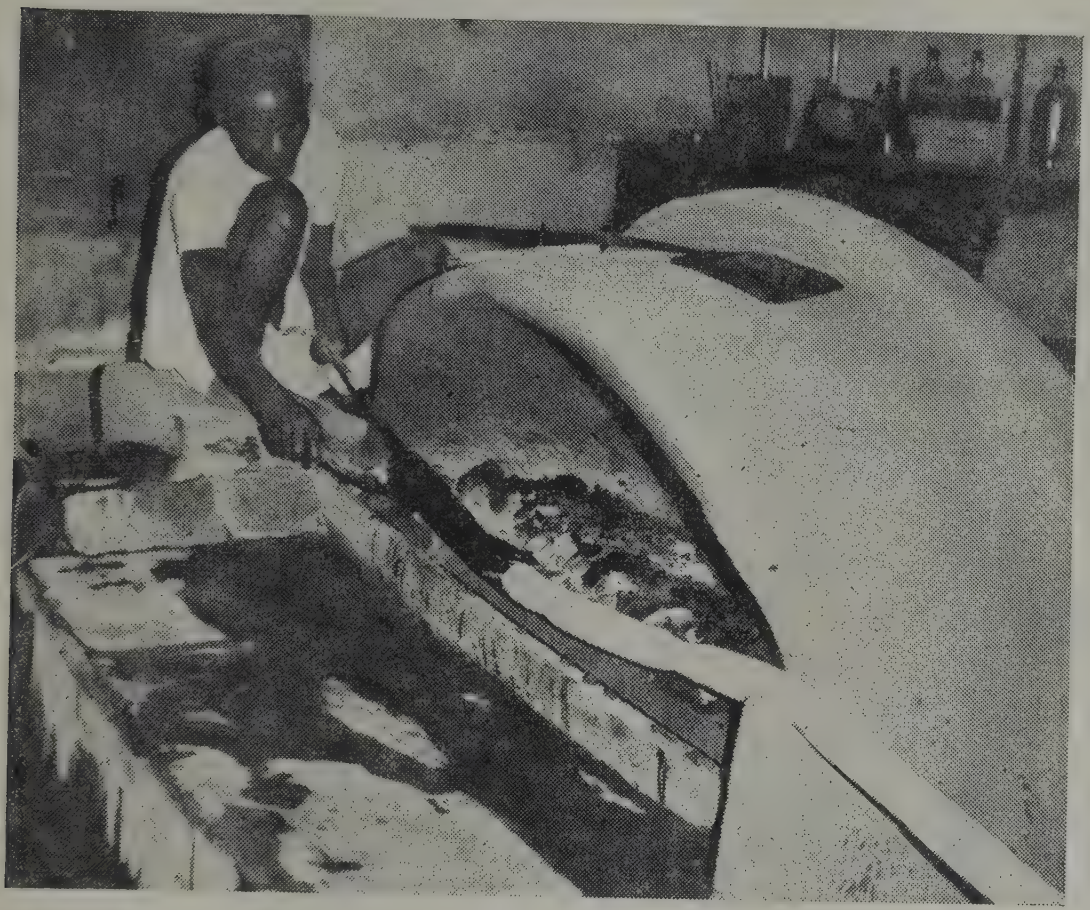
hand, another host, *galwang* (*Albizzia lucida*) which has been trained into bushes, has been shown to sustain lac insects during the summer months. Therefore for sustained lac production, a mixed plantation of *bhalia* for *aghani* crop and *galwang* for *Jethwi* crop has been recommended. It is possible to raise plantation of these mixed bushes under agricultural conditions on acre basis. *Bhalia* becomes ready for inoculation within one and a half years and *galwang* within three years from the time of raising. The raising of *bhalia* and *galwang* bushes from cuttings with the use of growth hormones has also been achieved. As all the operational schedules can be performed easily from the ground itself, the cost of cultivation in comparison to the conventional hosts will be greatly reduced. In these bushes the cropping operation itself serves the purpose of pruning and the bushes become ready for re-inoculation within a year and therefore, three coupes will be necessary in rotation.

Besides the above two hosts, *Khair* (*Acacea catechu*) and *porho* (*Ficus cunia*) also proved to be promising alternate hosts for *Kusmi* lac. To bring down the cost of cultivation, attempts were also made to train the conventional hosts into bushes to which *ber* and *palas* responded well. This has raised a hope of bringing these trained bushes into lac cultivation on plantation basis.

A successful crop can only be raised if healthy, mature and pest-free broodlac is selected for inoculation. The brood rate for inoculation also has some direct bearing on the yield of crop. It has been clearly established that the rate of broodlac should be such as to give settlement of lac larvae over 10 to 15 times the length of the brood sticks which are normally 15 to 30 cm in length.



Soft coke hearth for lac melting

Enemy insects of lac and their control. There are two kinds of enemy insects, parasites and predators. The parasites are small winged insects, called *Chalcids* which lay their eggs inside the lac tests and are responsible for damage to the extent of 5—10 per cent. The most important predators of insect are two moths, *Eublemma amabilis* and *Holcocera pulverea* whose larvae feed on the lac insects. The former moth has six generations in a year and the latter five. The damage caused by these pests is nearly 30—40 per cent and sometimes the total crop is damaged.

Various effective measures such as biological, cultural, chemical and mechanical have been attempted in order to control the above pests. These are based on the knowledge of the behaviour of the enemy insects and on the knowledge made available through detailed studies on the most important source of predators and parasites to lac crops which are broodlac and sticklac not used for brood purposes. Hence cultural and mechanical measures are most appropriate to attack the pests at the very source and biological and chemical control measures during the progress of the crops in the fields. The methods evolved for prevention of losses to a large extent are briefly described below:

(i) Healthy brood lac, free from enemy insect infestation, should be used for inoculation.

(ii) Self-inoculation of lac crops should be avoided as far as possible except where necessary because old lacs favour the spread of enemy insects.

(iii) The brood bundles used for inoculation should not be allowed to remain on the hosts beyond 2 to 3 weeks.

(iv) All lac sticks other than brood and all *phunki* brood (after use as brood lac) should be scraped at once and removed from the vicinity of inoculated hosts. Sufficient care should also be taken to destroy the larvae and pupae of the pests from the scraped lac.

(v) Wherever possible brood should be encased in 60—80 mesh brass wirenet baskets (30 cm × 7 cm) for inoculation particularly for areas where lac cultivation is being

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AMMONIUM SULPHATE 20.6%N
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KEEP IN DRY PLACE AND AWAY FROM WATER
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PRODUCTS OF HINDUSTAN STEEL

introduced for the first time. The baskets permit free passage to the lac larvae but not to the enemies.

(vi) The growing of *Rangeeni* lac in predominantly *Kusmi* areas and *vice versa* should not be encouraged as the pests from the more fully grown crops of one variety may infect the less mature crop of the other variety grown in the same area.

Chemical Control

Apart from above methods, the possibility of chemical control has been considered though great risk is involved in as much as the lac insects may get killed while controlling the key pests. The insecticides should be such that these will be non-toxic to the lac insects but sufficiently toxic to the pests so as to kill them. Though DDT and BHC as 5 per cent dust and 0.1—0.3 per cent sprays were found safe for the lac insects at all stages of development, these were not fully effective against the pests. Recent behavioral and feeding studies revealed that the newly hatched *E. amabilis* caterpillars show vigorous movements for a period varying from 2 to 12 hours before attacking any lac cell on the host plants. This observation provided an important clue for chemical control of this particular key pest. Screening of various modern insecticides revealed that a number of insecticides especially of hydrocarbon groups are harmless to the lac insect while harmful to caterpillars of *E. amabilis*. A very selective contact poison, namely Endosulfan (Thiodan) has been recently found to be very effective in controlling *E. amabilis* in a concentration of 0.03%; the emulsion being sprayed once after inoculation. Field trials are yet to be seen.

Since the continuous use of pesticides leads to resistant variety of insects, the only next best course left was to switch over to biological methods of control. To achieve this, attempts were made to utilise both the beneficial insects as well as the insect pathogens.

Both the predators have a good number of insect enemies but unfortunately, in nature, all these enemy insects occur in small proportions. In order to upset this balance, some of these most effective beneficial insects, *Bracon greeni*, *Apanteles tachardiae*, *Elasmus claripennis* and *Pristomerous sulci* were successfully bred in large numbers in the laboratory, and released in the fields. Though the results have shown promise they were not very satisfactory.

Microbial control has of late gained considerable importance in controlling insect pests control. One such microbial insecticide, *Bacillus thuringiensis*, a pathogenic bacteria, has proved to be very effective in controlling the two key pests even in field experiments. Further preliminary survey on the naturally occurring pathogens has revealed that the two predators are susceptible to a number of disease producing pathogens in their immature stages.

It will be evident from the above accounts that for effective control of parasites and predators an integrated approach needs to be evolved, and work in this direction has already been planned and is in progress.

Taxonomical studies have resulted in recording fourteen species till 1958 and a few more have since been added to this list. The lac insect was known as *Laccifer lacca* (Kerr) but recently has been rechristened as *Kerria lacca* (Kerr). Morphology, anatomy, bionomics and some aspects of physiology have also been studied. The biological complex of the lac insects has also been studied in details. The controversial mode of reproduction has been clarified through breeding and cytological analyses to enable definite genetical investigations possible in these insects. Thus it has been proved beyond all doubts that both *Rangeeni* and *Kusmi* strains reproduce sexually and no partheno-genetic reproduction occurs in either of the strains under any condition as was previously believed. Further studies on the reproductive activity have shown an unusual mating behaviour (lac females are usually mated to a number of males) which could allow these insects to retain genetic variation in their natural aggregates. More recently cytogenetic analysis have unravelled a unique genetic system in that the male lac insect transmits only the maternal genome through the sperm due to heterochromatisation and elimination of the paternal chromosome set during spermatogenesis. This knowledge now forms the basis of current and future genetic improvements in lac insects.

Study of the strain crosses in lac insects has shown that the *Kusmi* strain is genetically endowed to survive normally on *kusum* but not the *Rangeeni* and that the ability of *Kusmi* strain to survive is dominant to the inability of *Rangeeni* to do so.

Detailed life history of a number of pests, predators and beneficial parasite of the predators of lac insects as well as of pests of host plants have been studied in connection with their control.

In the Chemistry and Technology Divisions work on improved processing techniques, grading and analysis, modification of shellac for utilisation in new fields, fundamental work so as to gain an insight into the nature of the molecule and ad-hoc work as was referred from time to time were undertaken.

Improved methods of refining and manufacture

The conventional methods of seedlac and shellac manufacture were studied thoroughly and improvements made to produce economically seedlac of improved colour, lower bleach index, less impurities content and increased yield. Another development to eliminate the drudgery of workers is the fabrication and introduction of a machine for separating sand from seedlac. Regarding shellac manufacture, a major improvement is in evolving of the autoclave method which can be adopted by both small scale as well as large scale manufacturers. Conditions have been determined for substituting conventional wood charcoal with soft coke for the manufacture of shellac which substantively economises the shellac production. Conditions have also been determined and pilot plant fabricated for the successful manufacture, in our country, of stable bleached lac of both the regular (with full compliment of wax) and refined (without wax) varieties.

One of the most important achievements is the development of a process for the manufacture of shellac direct from sticklac. During the processing of sticklac to seedlac and then to shellac, there is a loss of 20 per cent of lac resin. This improved process has resulted in the recovery of almost all of the resin thereby eliminating the by-products and the shellac obtained has better properties than those manufactured by the conventional methods. Another advantage of the process is that waxy, dewaxed, and decolourised (with wax or without wax) shellacs can be prepared. This is a major breakthrough in the field of processing.

Economic Utilisation

Lac factory effluents contain sufficient amount of lac resin, wax and the total amount of water soluble lac dye. These are valuable products and their economic reclamation will necesarily add to the overall economy of the lac industry. Normally the effluents are allowed to drain out into the adjoining fields and due to the presence of insect bodies producing unhygienic atmosphere in the surroundings. A very simple process has been developed for hygienic disposal of these effluents stopping putrefaction. During this process the lac, wax and most of the dye are obtained as a slurry. Methods have been standardised for reclamation of these products from the slurry and the remaining dye from the mother liquor. To recover the wax from the slurry a wax extraction pilot plant has been assembled. The residue contains sufficient nitrogen and is a good source of manure.

The wax as obtained above or from refuse lacs is normally very dark coloured and as such has restricted uses though it happens to be a valuable product of commerce. A method has recently been developed for the manufacture of light coloured wax, from the crude wax, having higher melting point, better solvent retention power and low penetration value indicating harder wax. This achievement will lead to better utilisation of the dark coloured wax.

The by-products of lac industry such as *molamma*, *kunhi*, *kiri*, etc. contain sufficient amount of lac. In the absence of its reclamation and utilisation, these are accumulated and ultimately sold to Germany at a very cheap price. Successful methods have been developed for the manufacture of shellac, bleached lac and *total* hydrolysed lac from these by-products. These developments have opened up avenues for their utilisation in our country thereby adding economy to the lac industry.

Analysis and Grading

During the period under review a few new methods for determining some of the essential analytical requirements for lac were evolved. These are (i) a rapid method for the determination of moisture content, (ii) a modified and quick method for the determination of insoluble content, (iii) a method for the assay of lac resin in sticklac, (iv) a method for the differentiation between *Kusmi* and *Rangeeni* lacs, (v) a method for the determination of age of lac, and (vi) a simple and 'universal' method for the determination of the bleach index/bleachability. The last method has been accepted in the Indian Standard Specifications as the only method for the purpose and is under study for use in the international specifications.

Apart from the above analytical

Bleached lac pilot plant

methods, the Institute has also provided all technical help for the formulation of Indian and International Specifications for seedlac, shellac, bleached lac and sealing wax.

Fundamental Work

Physical

The thermal and electrical properties of lac, its constituents modifications and modified products were studied which have resulted in valuable information on the performance of shellac in the electrical industries and especially for the development of insulating varnishes based on lac. The determination of specific heat of various lacs has also led to the evolution of a method for assessing the age of lac.

Physico-Chemical

In this field, lac has been studied in the solid state as well as in solution form. Viscosity and osmotic pressure experiments indicated that in dilute solution lac is molecularly dispersed and the seemingly colloidal behaviour in concentrated solution is due to clusters of solvated complexes. Further, studies on the double refraction of lac solutions of varying velocity gradients and concentrations revealed a linear increase with velocity gradient indicating that lac molecules are neither flexible nor kinked. Studies on the kinetics of polymerisation of lac and its constituent acids have led to the understanding on the nature of polymerisation.

Organic

The baffling problem and one of the most important was the study of the nature of the lac molecule and its constituent fractions. During the period sufficient advances have been made towards this end. Patient and systematic studies with the help of conventional and modern chromatographic techniques on the constitution of lac resin and two of its components, namely the ether insoluble hard or pure resin and the ether soluble soft resin, have resulted in the isolation and identification of a number of new acids, both aliphatic hydroxy fatty and hydroxy sesquiterpenic acids. The structures of these constituent acids have also been established. The lac resin has been found to be made up of not less than nineteen constituent acids of which the major ones are aleuritic and jalaric acids. It is still not precisely known how these acids are combined together in the versatile lac resin.

From the present day knowledge it may be inferred that lac resin is composed of at least six components, the average molecule has free hydroxyl and carboxyl groups, a part of the vicinal hydroxyls of aleuritic acid and the aldehyde group of jalaric acid is combined and that ether, acetal, acylal and ester linkages are present.

The constitution of the water soluble lac dye (laccaic acid), another difficult problem, was also solved. It has been found to be composed of five components whose structures have been established conclusively. The structure of the water insoluble dye, erythrolaccin, which is responsible for the golden yellow colour of the resin has also been conclusively established.

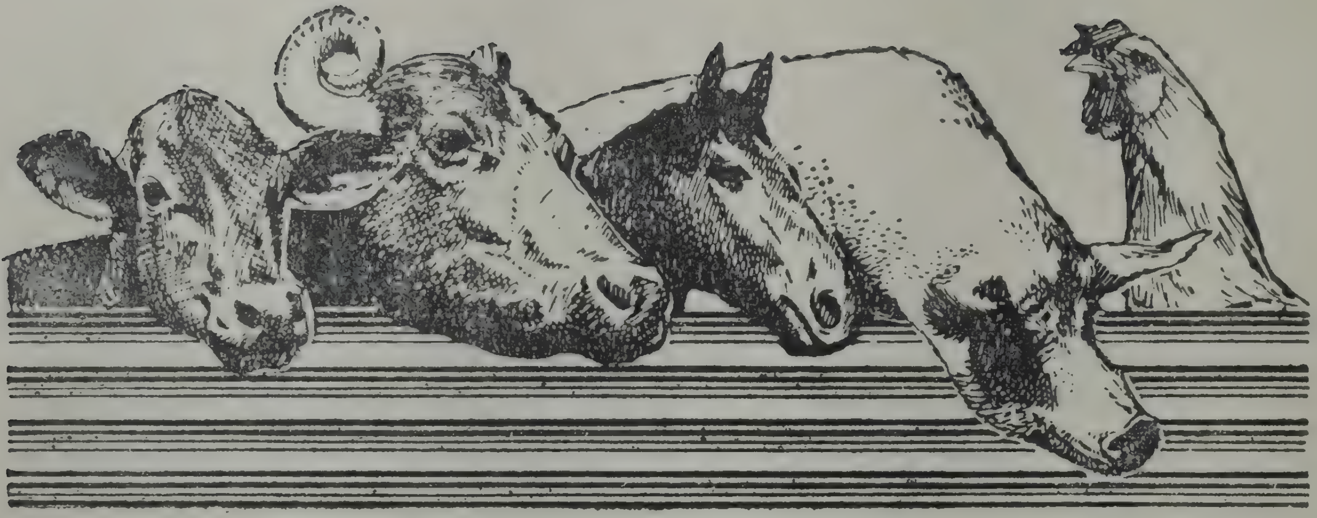
Modification and Utilisation

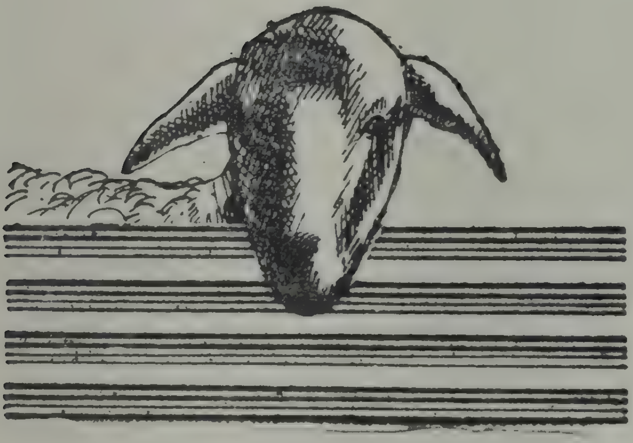
Due to its versatility lac has enjoyed a superiority over all other resins, natural or synthetic. But since the Second World War it is facing great competition from special purpose synthetic resins which have almost thrown it out of the gramophone industry, partially replaced it in the surface coating industry and are constantly threatening its use from other fields too. This is because of its well known limitations, namely low softening and melting points, poor water and solvent resistances, colour, brittleness and lack of specialised performance required by modern technology. To keep pace with the modern technological and exacting demands and also to stabilise its position vis-a-vis the competition from the expanding synthetic rivals, various attempts have been made and are being made in this Institute to modify lac for producing special purpose products of improved performances. A good measure of success has been achieved in individual directions which it is strongly believed, is helping in stabilising its position especially in surface coatings and electrical industries. These modified products have also opened up newer fields for its utilisation. Some of these are described below.

A water soluble variety of lac has been produced for coating of earthenware articles, which imparts glossy and water, heat, oil and soap resistant films after air drying or baking. The coated earthenwares are cheap substitute for the comparatively more expensive porcelain, china or glassware and are being adopted in increasing number of villages and village industries' associations. This modified lac also finds use in the manufacture of inks.

Etch primer or wash primer is quick-drying paint like composition which on application on metal surface produces passivation and gives on drying adherent base, for subsequent painting. A very successful composition has been developed using lac in place of polyvinyl butyral resin. It possesses outstanding adhesion to and acts as an effective anticorrosive primer for light metals and alloys and dries to a smooth, hard, matt and adherent film which may take any finishing paint.

Lac has been modified with butylated melamine formaldehyde resin and the spirit varnishes prepared from it, termed Melfolac, dries very quickly on any surface giving smooth, highly glossy and flexible films resistant to heat, water and spirituous liquors. Its performance compares well with the synthetic wood lacquers and thus ushering a new era in the utilisation of lac in the field of heat and water resistant coatings. In addition to its satisfactory performance in the





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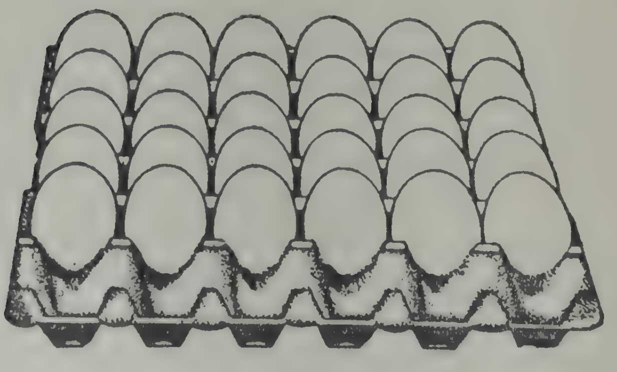

surface coating field, it also serves as a very good insulating varnish by virtue of its high breakdown voltage of 2.25 KV/mil which is nearly three times to that of parent lac. Heavy Machine Building Plant of the Heavy Engineering Corporation, Ranchi has found this varnish to be suitable for motor repairs.

Lac modified with urea or epoxy resin has been found to give films which are very suitable for internal coating of tin containers to be used for packaging of various consumer goods including lac varnishes and paints.

The modern trend is the development of aqueous varnishes. Apart from economy, it eliminates fire and health hazards in industrial establishments as well as for the consumers. On this line a few noteworthy developments in the lac based aqueous finishes have been achieved. Ammoniacal solution of lac has been found to be fully compatible with aqueous solutions of maleinised linseed oil and self-dispersing alkyds. Films from these blends have shown remarkable adhesion, elasticity, toughness, hardness, gloss and resistance to heat, water, chemical and most organic solvents. These varnishes also showed promise as vehicles for the formulation of anti-corrosive water thinned red oxide primers for steel. These have the added advantage of being highly suitable for deposition by the modern electrocoating technique, application conditions for which have also been standardised in the Institute. Recently interesting aqueous dispersions based on graft and copolymerisation products of lac with vinyl monomers have been developed which have given films of better hardness, flexibility and impact resistance than either of the products alone. For internal decoration of buildings normally costly and imported acrylic emulsions are used. In order to substitute this acrylic emulsion, two aqueous formulations based on lac have been developed which on limed or porous surface give smooth, hard and adherent films.

In connection with the economic utilisation of by-products of lac industry, an alcoholic method has been developed for the production of total hydrolysed lac from refuse lacs. This hydrolysed lac has been rebuilt to a new lac, termed *Rebulac*, simply by heating at 150°C. Baked films from ammoniacal solution showed outstanding flexibility, gloss, hardness and adhesion which was in direct contrast to aqueous lac varnishes which under similar conditions will flake off. Pigmented primers also behaved similarly. Another composition which can dry at room temperature to hard film as above has also been developed by heating a mixture of hydrolysed lac and linseed oil fatty acids in the ratio of 3:1. Since these primers give very glossy and hard finishes with good adhesion and flexibility, these show an important future promise in the field of surface coating for various ferrous and non-ferrous metals as a single coat finish.

Lac as such is incompatible with drying oils but on modification with rosin and glycerine becomes compatible. Such compositions are soluble in white spirit and have been found suitable for use as interior varnishes as well as clear baking oil insulating varnishes of the baking type and empire cloth. Compositions based on lac/castor oil or linseed oil and glycerine on treatment with toluene diisocyanate have been found to give air-dried films possessing good hardness, gloss, elasticity and resistance to water, solvents, acids and alkalies.

In our green revolution fertilizer has played and is playing an important role. The less the dissolution rate of these in soil the more of these will be available for healthy growth of crops. But the fertilizers are highly water, soluble and leach through the soil with rain or irrigation water, ultimately becoming unavailable to the plant in time of need. In order to decrease the dissolution rate so that most of the fertilizer is made available to the plant, a technique has been developed for coating urea granules with a composition based on lac and rosin. The rate of dissolution in water and the nitrogen content of this coated urea were found comparable with the T.V.A.'s sulphur coated urea. Preliminary agronomical trials so far have shown encouraging results.

Lac-rubber Combination

Lac and modified lacs have been found to be very useful compounding ingredient for synthetic as well as natural rubber. It acts as a processing aid with curing agents assisting in milling and mixing of the various rubber compounding ingredients. This compounding has given products of improved hardness, tensile and tear strength, impact resilience, modulus, ageing and swelling towards aliphatic and aromatic hydrocarbons.

It has further been observed that the incorporation of lac into natural rubber lowers the dielectric loss while the dielectric constant remains almost constant. These properties are of great use in the manufacture of cables as there will be very low power loss during electrical transmission.

As the use of rubber articles is increasing enormously in our daily life, it is felt that the incorporation of even a small proportion of lac in the manufacture of better quality rubber products will increase sufficiently the utilisation potential of lac to a greater extent.

Ad-hoc research. This Institute is the only one in the world devoted exclusively to lac research and a number of *ad-hoc* problems are referred for solution by interested parties from time to time. The problems solved were far too numerous to be listed here and only a few may be mentioned here, namely a dry mounting tissue paper for mounting photoprints, a lac cement for the fixing of brass caps to low wattage electric bulbs, a lac based cementing composition for tube light chokes, a method for utilisation of polymerised bleached lac for French polishing, iso-propyl alcohol as an alternate solvent to methylated spirit for French polish which is in short supply in our country, gasket shellac cements, etc.

PROSPECTS FOR ENHANCED RABI JOWAR PRODUCTION

N. GANGA PRASADA RAO*

IN view of the widespread failure of kharif rains, particularly in the states of Maharashtra, Mysore and Andhra Pradesh, where the bulk of jowar area of the country is located, there is emphasis on the prospects for compensating this loss in sorghum production by enhanced efforts during rabi. The prospects for such efforts are outlined in the light of the available research findings.

Rabi Areas

For purposes of rabi, the following broad areas may be considered:

Late kharif

The Maghi areas in the district of Khammam, Warangal and Karimnagar and the Nandyal valley of Kurnool District in Andhra Pradesh, the late kharif areas of Tamilnadu and the Surat District of Gujarat State where the plantings commence in late August—early September constitute the late kharif or mid-season tract. This area is wholly rainfed.

Traditional rabi

Traditional rabi jowar area is predominantly concentrated in the Deccan plateau covering the states of Maharashtra, Mysore and Andhra Pradesh. Rabi jowar constitutes nearly one-third of the total jowar area in the country. Since the crop is grown in the winter (mid-September—mid-October plantings) and matures slowly in clear weather, rabi jowars have a premium in the market and are always priced higher than kharif jowars. The traditional rabi jowars are almost wholly rainfed and come up with the residual moisture stored in these black cotton soil areas.

Irrigated summer season

The irrigated summer season (January-February plantings) is also clubbed under rabi for statistical purposes of the seasonal distribution of areas. This season is more analogous to the short-duration kharif and is predominantly distributed in Tamilnadu.

Impact of Research Effort on Production

Earlier work under the accelerated sorghum project and the All India Co-ordinated Sorghum Improvement Project was concentrated on kharif jowars. Rabi jowar improvement work under the AICSIP is of recent origin. A brief account of the implications of available research results on enhancing rabi jowar production are outlined.

Late kharif

Traditional varieties grown during this season, viz PJ22K in Khamam and Warangal, N3, N5, etc. of Nandyal in Kurnool District of Andhra Pradesh and BP53 of Gujarat are late and mature in 5-5½ months. In a situation marked by absence of July and August rains, short-duration hybrids and varieties have a decided advantage. Since these jowars mature in a clear weather, there is no possibility at all for grain deterioration also. Hence emphasis has to be laid on cultivation of CSH-1, CSH-2, CSH-3, PSH-2 or Swarna during this season. Depending on the availability of seed, any of these varieties could be taken up with recommended fertilizer and insect control schedules. It is recommended that only one variety be taken up in each area. Multiplicity of varieties in the same region should be avoided to prevent midge incidence.

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* Project Co-ordinator (Sorghum) and Head, IARI Regional Research Station, Rajendranagar, Hyderabad 30 (AP).

Traditional rabi

(a) *Varietal improvement.* M35-1 is the dominant variety in the entire region. This is known to be the most drought-resistant variety, also known for its grain quality.

Of the recent hybrids and varieties CSH-1 and BSH-2 did reasonably well provided shoot fly was controlled. In years characterised by drought (less of monsoon rains) the hybrids CSH-2 and CSH-3 being the earliest to mature during this season, gave satisfactory yields when locals and even M35-1 failed to make any grain. For example, at Bellary during the 71-72 rabi seasons, CSH-2 and CSH-3 yielded 1118 and 1097 kg/ha respectively when the locals completely failed. The comparative figures under extreme stress are summarised below :

TABLE 1. PERFORMANCE OF EARLY HYBRIDS AT BELLARY DURING 1971-72 UNDER EXTREME STRESS

Variety/Hybrid	*Grain yield* (kg/ha)
CSH-2	1118
CSH-3	1097
CSH-1	893
PSH-2	689
Local (M35-1)	20

Of the recent varieties and hybrids tested, the following were promising: *Varieties*: R-16, R-24, RCR-408; *Hybrids*: M31-2A × LSR-1. The variety R-16 and the hybrid M31-2A × LSR-1 have superior grain quality. Extensive agronomic investigations have been planned and they have a chance of release fairly shortly. Seed supplies will not be available during this year.

(b) *Agronomy.* Considerable amount of work has been done on dates of planting of rabi jowar. Traditionally, rabi jowar is planted towards the cessation of the south-west monsoon around October 15. Very frequently absence of moisture in the top soil at sowing places a limitation of fertilizer application which is almost absent with the rabi jowar farmer.

Extensive trials have indicated that advancing the dates of planting to mid-September, and even earlier in some of the areas, facilitates application of fertilizers, results in improved crop stands and the ultimate yield increases to the order of 80—100%. The improved variety R-16 performed particularly well under early plantings.

All the fertilizer for rabi jowar (60 kg P_2O_5 and 60—80 kg N/ha) should be applied basally. A recommendation to this effect has been available from the 1971 and 1972 All India Co-ordinated Sorghum Improvement Project workshops held at Jamnagar and Nagpur respectively.

(c) *Insect and disease control*

Shoot fly. Shoot fly has been the major pest. It was observed that in areas where kharif and rabi do not overlap, the fly incidence was low in early plantings. In regions like Marathwada where kharif and rabi overlap, early planting has a decided advantage for yield provided shootfly is controlled. Seed treatment with carbofuran 5 gm (A.I.) per 100 gm of seeds or phorate 10% G in seed furrow at 1.5 gm/m or Thiodemeton 5% G in seed furrow at 3.0 gm/m gave effective control of shoot fly.

Sugary disease. Sugary disease of the panicle is likely to appear during winter months when temperatures are cool. If occuring it could be controlled with sprays of 0.2% Ziram or 0.2% Thiram at 50 per cent flowering. In case midge appears, this could be combined with carbaryl.

Irrigated Summer

Nearly four lakh acres of sorghum are grown under irrigation in Tamilnadu, plantings taking place in February. Prospects are also bright for irrigated summer crop in Andhra Pradesh and Mysore where plantings during the latter half of January or early February are highly rewarding.

(a) *Varietal improvement.* The short-duration CSH-1 and Swarna perform outstandingly well during this season. Since maturity takes place during summer months the grain is clean and of good quality. A new hybrid 2077A × CS3541 has done well during this season but seed will not be available during this year.

With adequate fertilisation (60 kg P_2O_5/ha and 80 kg N/ha), insect control and 4-6 irrigations, yields of the order of 5000-6000 kg of grain per hectare have been realised.

Potentialities for such sorghums exist in the Nagarjunasagar Project areas, the Krishna, Godavari deltas of Andhra Pradesh and the Tungabhadra Project areas of Andhra Pradesh and Mysore. Paddy fallows of these states, with facilities for 3-5 irrigations after harvest of paddy are also potential areas.

(b) *Intercropping studies.* During the last summer season intercropping studies involving groundnut as the major crop and sorghum, soyabean, sunflower and castor as intercrops were taken up. The maximum return per acre was obtained with groundnut-sorghum intercropping system which was superior to pure crop of groundnut.

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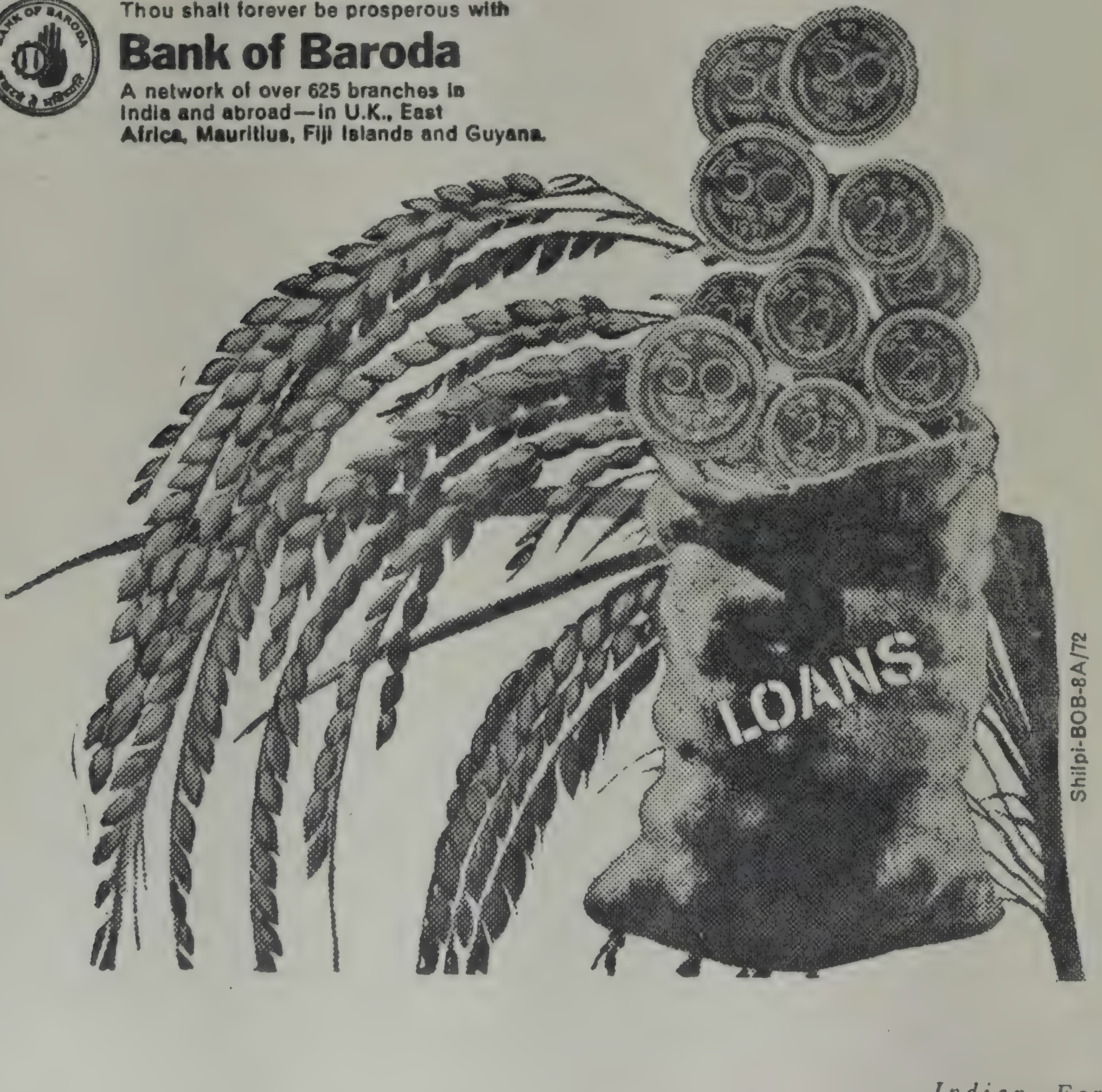

Shilpi-BOB-8A/72

The approximate distribution of summer irrigated groundnut is as follows:

State	*District*	*Area* (acres)	*Source of irrigation*
Andhra Pradesh	Nalgonda	90,000	Nagarjunasagar Project
	Guntur & Krishna	100,000	Nagarjunasagar Project
	Kurnool	85,000	Tungabhadra Low Level Canal and K.C. Canal
	Mahboobnagar	35,000	Rajoli Banda Diversion Scheme
	Chittoor	50,000	Tanks and Wells
	Anantapur	25,000	Tungabhadra Project High Level Canal
	Cuddapah	18,000	Wells
Mysore	Raichur	75,000	Tungabhadra Project
	Bellary	25,000	Tungabhadra Project High Level Canal
	Chitaldurg	65,000	Bhadra Project
	Shimoga	30,000	Tungabhadra Project and Bhadra Project
Tamil Nadu	South Arcot	100,000	Mostly under wells
	North Arcot	20,000	„
	Coimbatore	32,000	„
	Tanjore	21,000	„

Source of statistics: Oilseeds Directorate, Hyderabad

In at least some of these areas, if groundnut could be intercropped with an early maturing sorghum like Swarna or CSH-1 in the proportion of 1/6 to 1/10 to groundnut, substantial sorghum yields could be obtained.

The seed rate of groundnuts should not be reduced but a row of sorghum could be planted after every 6 to 8 rows of groundnut. Variations are possible as 2 rows of sorghum to 12 or 16 rows of groundnut and so on.

Groundnut-sorghum intercropping should be concentrated in January plantings of groundnut since growth of sorghum will be slow during December.

Summary and Recommendations

In view of the failure of July-August rains, particularly in the predominantly jowar-growing states of Maharashtra, Mysore and Andhra Pradesh, a substantial shortfall in kharif production is expected. Consequently, ways and means for compensating this loss during rabi have become necessary. The following guidelines to be suitably modified to suit local conditions, could be useful in planning for this enhanced rabi production.

1. *Rainfed rabi*

The production of rainfed rabi jowar is always a function of the amount and distribution of rainfall received during kharif season (South-West monsoon) since rabi jowar comes up with stored moisture in the profiles of the black cotton soils and almost no rains are received during crop growth. In view of the failure of rains during July-August and only one rainy month remaining ahead, the prospects for rainfed rabi will be fraught with difficulties.

1. The late kharif (*Maghi*) areas should be planted with early maturing hybrids as soon as the monsoon breaks.

2. As a rule planting of traditional rabi jowars should be advanced by a month. Plantings should commence in early September in Sholapur-Bijapur belt and early to mid-September in parts of Andhra Pradesh and Mysore. This would enable application of adequate quantities of fertilizers at plantings and results in establishment of satisfactory crop stands. Besides, some rain during early crop growth period could be expected which would be beneficial. Such plantings enable the crop to mature before the soil profile gets depleted of moisture. Since seed may be a limitation with hybrids, traditional varieties could be used. M35-1, CSH-1 and PSH-2 could all be used.

3. If plantings are delayed or if September rains are also inadequate resulting in early moisture stress, extremely early hybrids like CSH-2 and CSH-3 will give reasonable yields where the late locals are apt to fail. Depending upon the future rainfall pattern, these varieties could be capitalised under extreme stress.

4. Fertilisation in rabi should all be basal and should give 60 kg P_2O_5/ha and 60–80 kg N/ha.

5. Shoot fly control may be achieved by applying *one* of the following treatments: (a) seed treatment with carbofuran 5 gm (A.I.) per 100 gm of seeds or (b) phorate (Thimet) 10 per cent granules in seed furrow at 1.5 gm/metre row or Thiodemeton 5 per cent granules in seed furrow at 3.0 gm/metre row or adapting a slightly higher seed rate and thinning affected plants three weeks after sowing.

6. Sugary disease of ears and midge if occurring may be controlled by 0.2% Ziram or Thiram sprays alone or in combination with carbaryl (50% WP) 3 kg in 500—600 litres of water per hectare for midge control at 50 per cent flowering.

Irrigated Summer

While rainfed rabi production is dependent on preceding rains, prospects for additional production during irrigated summer may be considered assured.

It is possible to plan for a targetted additional production and every additional acre could yield 1-2 tons of grain. It is, therefore, suggested that this should be attempted in concentrated areas in Andhra Pradesh (Nagarjunasagar, Tungabhadra, Krishna and Godavari deltas), Mysore (Tungabhadra and Bhadra Project areas) and Tamilnadu (wells).

1. The early duration CSH-1, CSH-2 and Swarna could be grown in pure crops under the projects. The paddy fallows offer potential scope. It is necessary to provide price support here since the local people are not accustomed to consume jowar. Jowar grains from these areas could be procured and taken to jowar consuming areas.

The fertilizer and insect control schedules remain the same as described in the preceding paragraphs and 3–6 irrigations will be needed during crop growth. Plantings should be done from January 14th onwards to the first week of February.

2. There is a substantial area under irrigated groundnut in the states of Andhra Pradesh, Mysore and Tamilnadu. Groundnut plantings commence during December and extend into January-February. All areas where groundnut plantings commence from January onwards could have a component of the short-duration varieties or hybrid, viz. Swarna or CSH-1 or PSH-2 in the proportion of one row of jowar to 6–8 rows of groundnut. Seed rate of groundnut should not be reduced. The basal dressing of fertilizers should be common to both crops but jowar alone may get side-dressed at 30–40 days to give additional 30–40 kg N/ha. This would add a substantial amount of food and fodder without any major loss in groundnut production.

Prospects for any targetted additional production are greater during the irrigated summer in view of the time available for planting and also in view of the assured irrigation. There is apparently no risk involved.

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ROLE OF BAJRA IN INDIAN AGRICULTURE

B. R. MURTY
Project Coordinator
All India Millet Improvement Programme
Indian Agricultural Research Institute, New Delhi

THE cultivation of millets in India has been confined to areas where no other crop can do better than this group of crops under moisture stress and limited soil fertility. Practically all of them except ragi (finger millet), are grown in areas of scanty rainfall of less than 20" in sandy and poor soils. However, millets as a whole have a deeper root system with better extraction of soil moisture and their capacity and its utilization, their efficient photosynthetic mechanism and rapid transfer of food material for the leaf of the grains and their capacity have made them suitable to stand serious drought in *barani* areas. Besides, the grains have a higher and more balanced protein content (9 to 15 per cent in bajra, and higher in Setaria) having a biological value similar to or better than wheat and imparts substantial energy to the body with easy digestability. The fodder of the new hybrids is excellent for grazing as well as hay while the dry fodder can be used only under extreme scarcity conditions.

The areas of cultivation of bajra in our country can be divided into four ecological zones.

1. Adequate to abundant rainfall and fertile soil (Punjab, U.P., Delhi, East Rajasthan and adjacent M.P.) with 200 cm rainfall.
2. Limited moisture and heavy to light loams as in Gujarat, Maharashtra, South Madhya Pradesh and N.W. Andhra (about 140 cm rainfall)
3. Low moisture and light soils as Mysore, Deccan and Rajasthan (60 to 70 cm).
4. Limited moisture but well distributed rainfall zone, Madras, Coastal Andhra and Orissa (90-100 cm).

Role of the Hybrids

These zones are based on rainfall distribution and soil fertility. With the availability of hybrid bajra, which is capable of doing well under all these conditions, the yield levels have risen several fold more than the national average of 3 q/ha with the local varieties and have transformed the role of this crop from subsistence areas to areas of intensive agriculture. The area under bajra has changed from nearly 8 million hectares during 1947-48 to about 10 million hectares in 1971-72 with a peak of 12.9 million hectares during 1970-71. However, the production which remained static till 1964-65, about 2.3 million tonnes, nearly increased four-fold in 1970-71 with very little change in the area. This four-fold increase has been mainly due to the impact of hybrid bajra which covered about 11% of the total area. The seed production of hybrid bajra by the National Seeds Corporation commenced in 1966 over an area of one thousand hectares and a production 4000 quintals of seed as compared to 5265 hectares and a production of 18000 quintals of seed. It is expected that the other agencies produced an equal quantity but no firm estimates are available. The production of ragi has increased during the past 2½ decades from 1.3 million tonnes to 2.2 million tonnes with no change in the area while under the minor millets, the area and production have remained essentially the same, about 1.8 million tonnes over an area of 4 to 4½ million hectares. The high-yielding varieties programme which started in 1965 took advantage of hybrid bajra. Subsequently, three more hybrids have been released. Before the advent of hybrids, the main emphasis was on mass selection, group breeding, intervarial hybridization and single plant selections within the varieties available in this country (Pandya *et al* 1955 Chawan *et al* 1955). A number of varieties were released but none of the varieties could make much headway. This was because of limited variability available within this country and no efforts were made to introduce variability from the centres of origin or even to exploit the material available within the country.

Efforts were also made to produce hybrids of bajra by taking advantage of protogynous nature of this crop. Two hybrids X1, X2, X3 from Madras State and one Sel 28-15-1 × AF3C-1-C-1 from Bombay (Chawan 1955) were released for general cultivation. This was possible by mixing two inbreds in equal quantity and planting them closely in the field in an isolated peat for random mating. These hybrids could not make much of impact as the yield level could not be raised beyond 10 per cent of the locals. This was probably due to predominance of selfed or sibbed seeds in these hybrids owing to limited intercrossing.

During this period prior to 1965, a number of varieties with a maturity range of 75 to 125 days were produced with a majority of them having a level around four to six quintals per hectare and 15 to 20 quintals under irrigated conditions.

During the period from 1965 to 1971 four hybrids of bajra, three of ragi and one of Setaria were released. Two more hybrids have been recommended for release during 1971-72 and one more variety of Setaria. The yield performance of these hybrids in relation to the locals under the national demonstrations during 1971 are given below:

Hybrid	*No. of Demonstrations*	*Grain yield Q/ha*	*Average*
HB1	86	8 to 27	25.6
HB3	28	32—34	32.8
HB4	37	11—57	37.8
J104	6	32	32.3

RELATIVE PERFORMANCE OF HIGH YIELDING VARIETIES/HYBRIDES OF BAJRA AND *RAGI* UNDER RAINFED CONDITIONS

Bajra		*Ragi*	
Hybrid Year of release	*Yield Q/ha* (1967-72)	*Variety Year of release*	*Yield Q/ha* (1969-72)
Local (Maximum)	14.0	Local (Maximum)	20.6
HB5 (1972)	23.9	IE28* (1972)	26.2
HB4 (1968)	22.3	EC4840** (1972)	25.1
HB3 (1968)	23.8	Sarda (1970)	27.8
HB1 (1965)	20.7		

* Tolerant to mosaic & blast

** Tolerant to mosaic

Recently with increasing yield levels there is an increase in the incidence of diseases particularly ergot and downy mildew for which there was no resistance even in the local varieties cultivated over long period in our country. The utilization of heterosis by exploiting cytoplasmic genetic male sterility with the male steriles Tift 23 A and Tift 18A, of which the former responds to be a good combiner but is susceptible to the disease, has added a new dimension to disease incidence. Using Tift 23A, but with better male parents with resistance, a hybrid $23D_2A \times J$ 934 developed at Jamnagar has been found to be having only traces of incidence of downy mildew and was recommended for release during 1972. Another hybrid $J126D_2A$ J 1270 with a high degree of resistance to downy mildew is in advanced stage of testing and is under pre-release multiplication. Resistance to ergot is not yet at a satisfactory level but prophylactic measures and chemical control are available. Based on an intensified activity during the past two years it has been possible to accelerate the programme and as a result two male steriles which are field resistant to downy mildew, and two mutants resistant to downy mildew have been identified and recommended for multiplication of release. In the case of ragi, a similar attempt has resulted in the isolation of a variety IE 28 resistant to mosaic and two other vaieties Sarada and EC 4840 with moderate resistance to blast.

From Traditional to Modern

This transformation in which bajra played important role particularly under moisture stress has been mainly by the exploitation of hybrids and mobilization of germplasm consisting of more than 2000 accesions of bajra and about 10,000 stocks of other minor millets collected from over 20 countries, in Asia, Africa and Western Hemisphere mostly from the breeders and to some extent from the farmers' collections. This material has been assembled during 1967 at IARI and evaluated and classified and catalogued. They were tested in a diversity of 13 environments ranging from 8° North to 32° North all over India. From this material, a number of lines with high protein content, high degree of resistance, large ear size and regeneration capacity have been identified and incorporated in the breeding programme.

Exploitation of heterosis. The spontaneous occurrence of cytoplasmic male sterility in bajra was reported by Dr. Burton from USA in 1958 and the first ever cytoplasmic male sterile line Tifton MS. 23A was received in this country during 1962 from Dr. Burton. This opened the door for commercial exploitation of hybrid vigour in bajra and the first ever hybrid using an Indian parent Bil 3 B and male sterile line Tifton 23 A was released during 1965 for general cultivation for rainfed as well as irrigated areas of the country. The hybrid became popular immediately after release and since a number of others were tested and HB2 and HB3 for rainfed areas with limited moisture stress and HB4 for adeqate rainfall areas were released. Another hybrid called HB5 or K559 was recommended for release during 1972 for limited and adequate rainfall areas.

As mentioned earlier, the impact has been on exploitation of hybrid vigour using cytoplasmic male sterile developed by Burton of U.S.A. However, simultaneous attempts and development of other sources of male sterility have resulted in the isolation of four more male steriles namely, 239 D2A, 110S1, S2, S3, J126 D$_2$A and MS628A. None of them however, were found to be resistant to the new disease of downy mildew except in the case of MS268A and a new male sterile developed by Jamnagar J126D$_2$A.

In all the released hybrids Tifton 23A has been the only M.S. line used so far. A number of male sterile lines are now available with different cytoplasm, which are now being used for the production of new hybrids. These male sterile lines are comparatively more resistant to downy mildew and other leaf diseases than Tifton 23A, which of late has been found to be highly susceptible to all diseases as can be seen below.

Tifton 23D$_2$A —Dwarf counterpart of M.S. 23A.
M.S.J. 126D$_2$A —Susceptible to disease, comparatively resistant to downy mildew
MS. 18D$_2$A —Moderately dwarf fairly resistant to green ear.
M.S. 628A —Tolerant to downy mildew and other diseases. Height similar to M.S. 23A.
MS. 110S$_2$A —Each of the three lines differ in
MS. 110S$_2$A respect of sterile cytoplasm.
M.S. 110SA$_3$ These have sources other than M.S. 23A cytoplasm but all are susceptible.

A number of other lines through use of mutation technique are under evaluation. Two lines M.L. 22 and M.L. 23 derived through mutation are also under test for disease resistance especially for downy mildew. A backcross programme through the use of ergot and downy mildew disease resistant donors is also under way to introduce disease resistance to the existing male sterile lines and elite inbreds.

IADP Programme

IADP Programme intended for wheat and rice has been extended to bajra on a limited scale, particularly, in Punjab and U.P. The contribution of bajra to the total of the production under the high-yielding programme was nearly 11 per cent of the total net additional income of 1600 crores of rupee/year generated by the programme. The coverage by high-yielding varieties of bajra was 1.42m hectare during 1970-71 and the total production exceeded the target of 8 million tons in the Fourth Plan.

Change in photo-sensitivity and maturity. New hybrids of bajra have a range of maturity of 80-90 days as compared to a majority of the local having 90 to 95 days and some with 120 to 125 days particularly those from Madhya Pradesh. Most of the collections from West Africa are highly photosensitive and tall, over 200 cm with long internodes. They are also non-synchronous in tillering. The first hybrid released has been based on the photo-insensitivity of the male sterile line Tift 23A which flowers in 52 days and matures in 80 to 85 days. The other hybirds also had a similar range of flowering and maturity with about one week extension in HB4. With the availability of dwarfing genes, it has been possible to convert both the male steriles and male parents into dwarf counterparts and a number of hybrids with a dwarf plant type and high harvest index have been now identified. The production levels of some of these dwarf hydrids ranged from 19 to 23 quintals of grain per hectare under rainfed conditions.

Testing for wide adaptation. These hybrids have been tested over a number of locations in the four ecological zones for a period of two to three years and on the basis of the results it has been possible to identify suitable parents with stability in production and stability for flowering time. It was observed that the hybrids have a capacity of at least 50 per cent better resistance over the locals while the basic yield level have more than doubled.

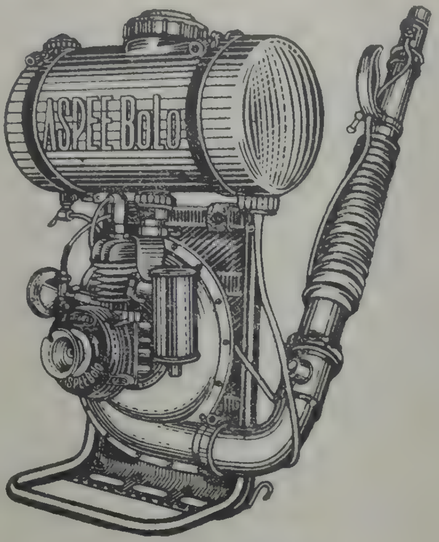
The performance of the hybrids and the other varieties during the past four years and under limited moisture and other conditions are 50 to 100 per cent better than the locals. The new hybrids are better in response than the earlier hybrids by 10-30 per cent depending on the environment.

Disease Resistance

A number of diseases attack the bajra plant. Most important of these are ergot and green ear (downy mildew) for North India and rust and ergot in the South. A number of donors for downy mildew from Nigeria, Senegal, Ethiopia and other places are available and are being currently used as donors in the improvement of existing high combining inbreds and male sterile. Kano 440, Kano 2436, Kano 2437, ACC 238, ACC 239, Kanpur 1984, Kanpur 1987 are donors for resistance to downy mildew and I.P. 2065, IP 2282, IP 1961, IP 1967 for resistance to both ergot and downy mildew.

A programme of mutational rectification of the existing male sterile lines and good inbreds is already under progress. Some encouraging results in respect of downy mildew resistance have already been achieved in respect of male sterile and elite inbreds like K. 560, K. 530, K 559, K 230 whose hybrids are also good. The dwarf counterparts of these inbreds have also been obtained with a good level of resistance to downy mildew.

Nutrition quality. The percentage of protein in bajra grains is about 10 to 14 per cent. None of the hybrids released so far gives more than 15 per cent protein.



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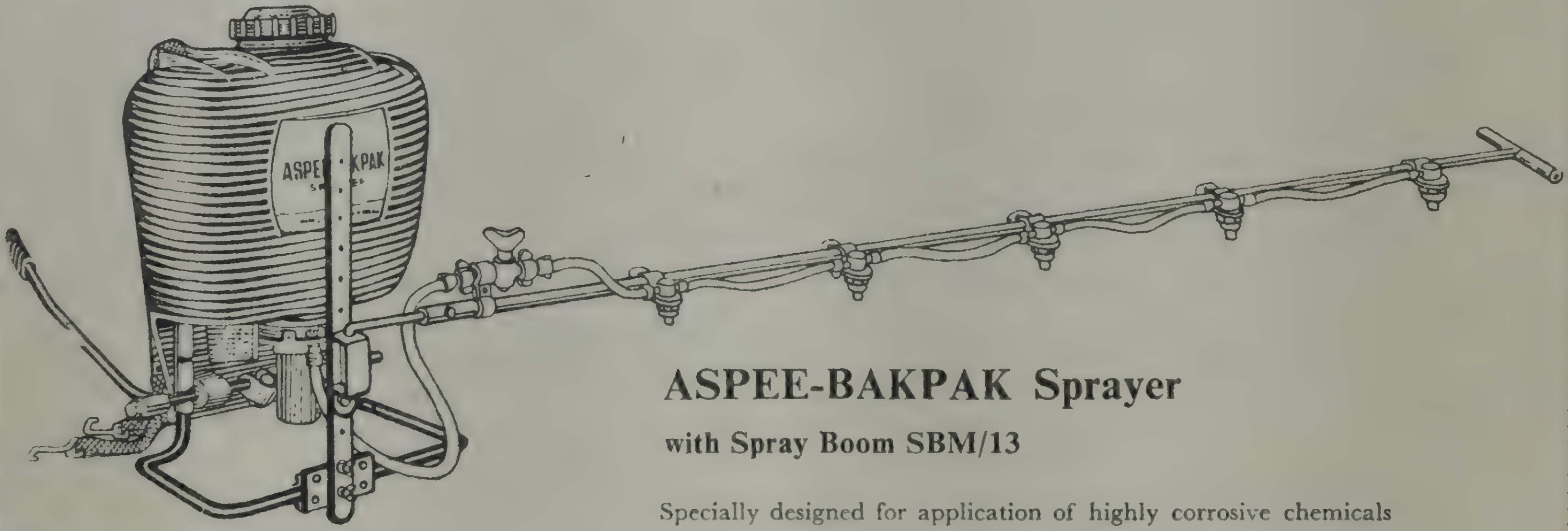

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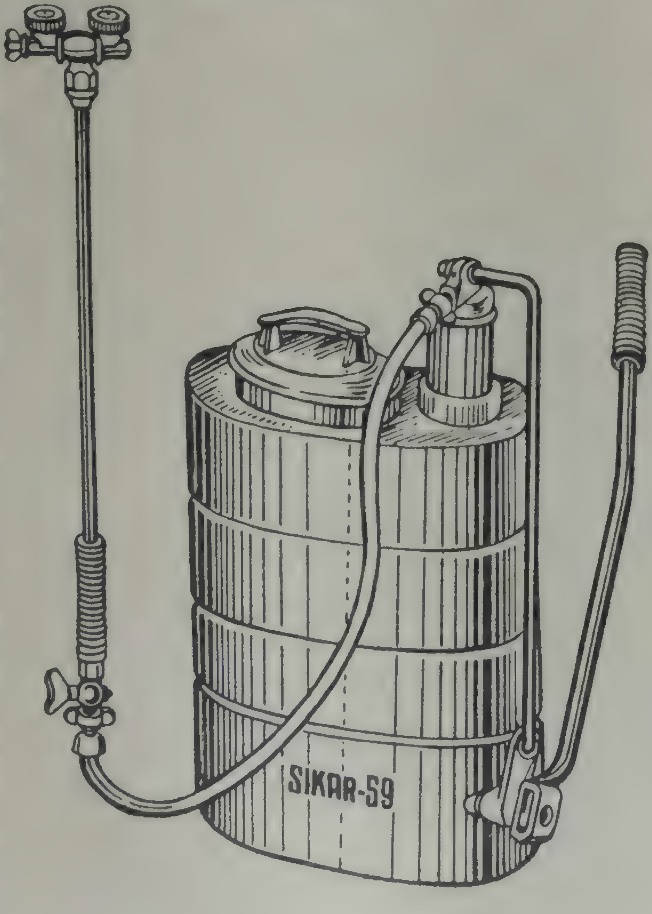

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Alternate use of millets. Millets in general are consumed in the form of 'Atta'. In view of the increased production of millets grains, some research on alternate use of millets needs immediate attention. The possible lines of research would be as below :

1. Use of millet grains as poultry and pig feeds.
2. Use of millet grain in biscuit industry.
3. Use of millet grains in brewing industry.
4. As a mixture with wheat or sorghum 'Atta' for better nutritional quality.
5. As a feed to cattle.

A programme to emphasize the importance of bajra as a green fodder for milching cattle to replace the traditional sorghum and maize fodder should be given top priority. Bajra is a quick growing fodder and stands two or three cuttings.

Integrated pest and disease control. An effective control of white grub which is serious in light soils of Rajasthan by the application of Lindane granules at 2 kg AI/ha has improved the survival from 1 per cent in control to 79.97 per cent in treated plots. The number of grubs were also reduced from 7.3 to .5/cc. The control of shootfly by the application of endosulfan spray has improved the seed yield by 875 kg/ha, which would otherwise have resulted in a loss of grain by 36 per cent. At the seedling stage use of 10 per cent granules or 5 per cent disulfoton with 1.5 per cent 3 gm/meter in seed rows at the time of sowing has controlled shootfly. For infestation at a later stage, a spray of endosulfan (35 per cent) will control shootfly and midge. The incorporation of bristles against bird damage has reduced the damage from 97 per cent to 50 per cent.

The streak virus of bajra was found to be capable of transmission to maize, sorghum, ragi and other grasses including weeds. The vector *Cicadulina bipunctella*, a jassid can be chemically controlled by the application of carbofuron as a drench for seedling before transplanting supplemented by side-dressing of the same by 2.5 kg AI/ha.

Under plant protection, an excellent method of creating artificial epiphytotics of downy mildew has been standardised for rapid screening of the material. The seed-borne nature of downy mildew in bajra and ragi has been established. A foliar spray of miltox or thiram along with seed treatment is found to appreciably reduce the secondary spread of downy mildew. Seed treatment with 2 per cent common salt solution and removal of sclerotia is effective against ergot, followed by spray of 0.2 per cent ziran at flowering.

Agronomy of rainfed areas and multiple cropping in dryland areas. In the agronomical trials, sowing of bajra in early July, with a split dose of nitrogen (80-100 kg under rainfed conditions and 100-120 under irrigated conditions) with a plant population of 175,000/ha with a row spacing of 45 cm is recommended. The incidence of downy mildew and ergot is found to double if the sowings are deayed beyond the first half of July. Under rainfed conditions, it is recommended to bring earlier the sowings to the first week of July at 2 cm depth in dry seed bed. The optimum response to fertilizer was found to be at 80 kg N+40 kg P_2O_5 and 40 kg K_2O/ha. Weed control by the application of propazine and atrazine at 0.5 kg of active ingredient has been as effective as repeated hand-weeding and improved the yield from 13.6 q to 26 q/ha in Delhi and Coimbatore. A protective irrigation at anthesis in areas of water availability is also recommended. Intercropping of hybrid bajra under barani conditions with groundnut or castor has substantially increased the net economic returns from Rs 2400/ha in pure bajra to Rs 2730/ha. Similar studies on fertilization and time of sowing under rainfed conditions are under way in ragi.

Fodder. Two interspecific hybrids for fodder Pusa Giant Napier of IARI and NB-21 of Ludhiana are released. Among them, NB-21 has yielded, on an average, 41 per cent more green fodder over Pusa Giant Napier. Its protein content is 12.6 per cent and oxalic acid 2.06 per cent as compared to 9.3 per cent and 3.0 per cent respectively of Pusa Giant Napier. On an annual basis NB-21 gave 78 per cent more yield/ha than Pusa Giant. Further selection of clonal populations in the interspecific hybrids is in progress for evolving a better hybrid than NB-21. The biochemical and digestibility studies of NB-21 revealed its better response to phosphatic fertilizer, with better regeneration capacity, more amenability for silage, but needs to be cut at a younger stage since the quality of its green fodder is found to go down with the advance of maturity. Among the annual types, the hybrid K 677 of Kanpur is found to be the best so far.

National Demonstration. In the 22 national demonstrations laid out with bajra during 1971, the all India mean yield was 28.8 q/ha with the highest of 61.3 q/ha in Andhra Pradesh. In the case of ragi, the national average of 22 demonstrations was 35.5 q/ha with a maximum of 60 q/ha in Mysore. Among the three crop rotations, bajra-paddy-paddy gave a mean yield 137.5 q/ha in Tamil Nadu. Among the two-crop rotations with bajra-wheat, the average was 77 q/ha. The maximum net return obtained by the farmers was Rs 7637/ha. The mean yield of bajra demonstrations under barani conditions was 18.6 q/ha with a maximum of 30 q/ha in U.P.

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PUSHKAR NATH BHAT
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CATTLE husbandry in India has essentially been a subsidiary occupation of farmers under a mixed farming system. In the past there were various distinct tracts of cattle breeding where good milch animals have been known, particularly Montgomery-Sahiwal tract for Sahiwal, Sindh for Tharparkar and Red Sindhi, Haryana for dual-purpose breed Haryana. Good draft animals have been known of Nagour breed in Rajasthan and Hallikar and Amrit Mahal in Mysore State. These animals have been essentially used for draft purposes.

Under the various farm practices, wherever draft animals have been kept, the farmer always maintained the buffalo for milk and cows for his bullocks. Barring these few well-defined tracts, large bulk of cattle in the Indian sub-continent are of non-descript type with very poor-yielding capacity. No serious attempt was made to investigate into the problems of cattle development and breeding, until the Royal Commission's visit.

The Royal Commission on Agriculture, which went into the cattle situation four decades ago, were also of the view that selective breeding amongst breeds of all-India importance and grading up of the non-descript cattle population by pedigreed bulls should prove adequate. It was considered good enough to upgrade the non-descript animals in the country with better developed dairy breeds in order to produce a dual-purpose animal which would give some milk and would be useful for work and for manure. This was the cornerstone of genetic improvement with regard to cattle for almost three decades.

With the rapid improvement in milk quantity and quality abroad and deficiency of milk and its products in this country, it was felt that the policy being followed for development was not yielding very fruitful results. With the inception of Division of Animal Genetics at I.V.R.I., a focal point for genetic improvement of livestock species was created which was responsible for considerable improvement in mental attitudes of both administrators and scientists. The general impression till then of the administrators was that India possessed some very good dairy breeds which had excellent quality for draft and were disease-resistant and that any introduction of better improved European dairy breeds would be difficult to manage and would prove disastrous in the country.

To answer critically these questions, livestock breeding farms were created by State as well as the Central Government. The results of research carried on cattle breeding for couple of decades with indigenous breeds showed conclusively that the Indian breeds of cattle had very slow growth, late age at maturity, long calving intervals and relatively very poor milk yields. The milk yields of better known breeds varied from 900-2000 kg per lactation, 900 kg for Haryana and 2000 kg for Sahiwal, barring a few animals which might have produced around 4000 kg in a lactation. The breed averages for these indigenous breeds for milk production and other traits are summarised in Table 1.

This alarming situation with regard to poor genetic potential of these animals can be visualised from the fact that 1/5th of the total world cattle population is in India and our per year milk production is only 24.9 million tons. The average milk production for cows is 173 kg as compared to the average milk production of 3500-4000 kg for cows in countries advanced in animal husbandry. It will become obvious that dairy industry in India will continue to be highly uneconomic if these low producing animals are to remain as the main producers of milk.

With these factors in view, a number of breeding methods were suggested. One of the suggestions made was a scheme of grading up with any one of the developed European breeds. The information available from a somewhat planned experiment in the Military Dairy farms, where crossing of Friesian with various Indian breeds of cattle has been practised for considerable length of time, has shown that it was possible to almost double the milk production by introducing 50% exotic inheritance and one could safely introduce up to 75% of Friesian inheritance in order to have a tropicalised cow. From a number of schemes started by the Indian Council of Agricultural Research to study the effect of Jersey inheritance on non-descript cattle it was also observed that a large increase in milk production was registered in F_1s. The results of both the experiments are summarised in Table 2.

It has been shown conclusively that while a non-descript cow produced 466 kg of milk on an average in a lactation, her daughter from a Jersey bull would produce, on an average, around 1334 kg of milk and a 3/4th Jersey daughter would produce around 1700 kg of milk with very slight change in the present animal husbandry technology except some improvement in forage feeding.

It has, therefore, become obvious that the purebred exotic cattle from various countries and their crosses will survive under tropical climate without very many problems if animal husbandry technology (management and animal health) is improved.

New Approaches Through Breeding and Frozen Germplasm (Semen)

In the year 1966 at Haringhata

TABLE 1. AVERAGES OF VARIOUS ECONOMIC TRAITS IN INDIAN CATTLE

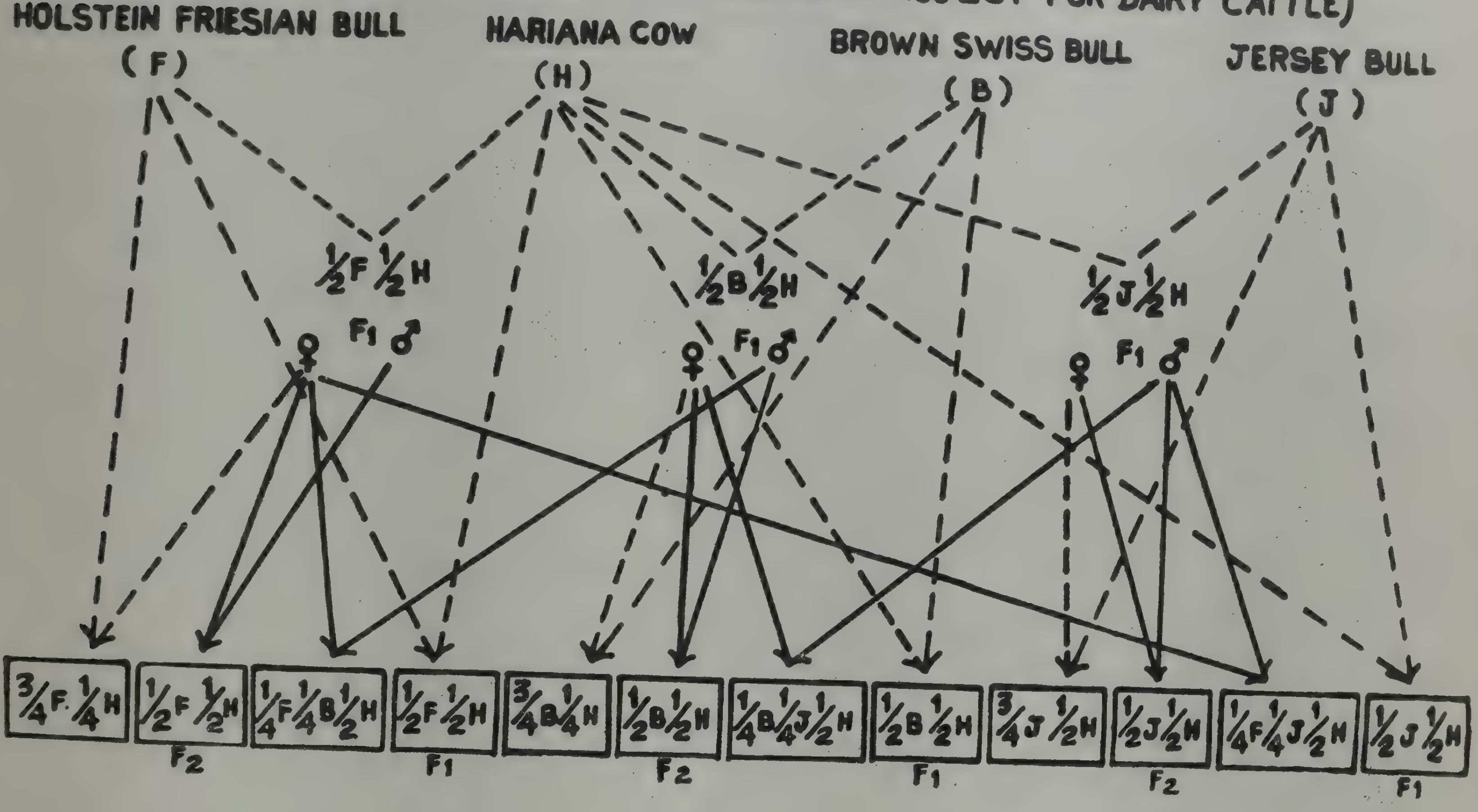
Breed	*Milk yield (kg)*	*Lactation length (days)*	*Calving interval (months)*	*Age at first calving (months)*
Sahiwal	1597.2±31.2	288.3±3.6	15.3±0.3	41.5±0.4
Haryana	1098.0±39.6	242.1±5.5	13.1±0.2	40.2±0.4
Tharparkar	1286.5±114.5	248.2±16.9	14.5±0.9	37.6±0.6
Red Sindhi	1534.9±32.2	284.1±3.8	14.5±0.4	39.2±0.4
Gir	1125.5±31.7	257.4±4.6	14.6±0.3	40.0±0.4
Kankrej	1256.0	353.0	16.2±0.4	47.4±0.8
Kangayam	643.6	264.0±3.3	16.7±0.3	44.1±0.4
Non-descript	534.7	30.30	21.1	59.0

TABLE 2. AVERAGES OF VARIOUS ECONOMIC TRAITS IN CROSSBRED CATTLE

Breed		*Milk yield (kg)*	*Lactation length (days)*	*Calving interval (months)*	*Age at first calving (months)*
Holstein × Sahiwal	1/2	1983.7±48.0	278.9±4.1	13.66	37.3
	5/8	2106.6±45.8	289.0±4.3	13.55	36.5
	3/4	2146.9±45.3	290.5±4.4	13.95	37.6
Holstein × Haryana	1/2	2372.7±55.9	335.7±7.2	15.1±0.4	35.5±0.5
	3/4	2431.3±177.0	299.6±10.1	15.5±1.3	35.3±0.8
Holstein × Tharparkar	1/2	2642.3±185.4	306.9±16.9	13.9±0.6	33.5±0.6
Freisian × Red Sindhi	1/2	2326.2±94.2	283.8±8.4	12.3±0.4	29.0±0.6
Red Dane × Red Sindhi	1/2	2213.8±115.5	267.1±9.5	11.7±0.3	28.3±1.2
Friesian × Gir	1/2	2154.2±106.3	281.8±7.1	12.9±0.4	34.9±0.5
Jersey × Red Sindhi	1/2	1968.3	—	13.8	29.0
Brown Swiss × Red Sindhi	1/2	1885.8	—	—	—
Jersey × Non-descript	1/2	1334.9	331.7	16.2±1.2	30.3±1.8

Fig.1

DIAGRAMATIC REPRESENTATION OF BREEDING PROGRAMME FOR EVOLVING A NEW BREED OF DAIRY COW (ALL INDIA COORDINATED RESEARCH PROJECT FOR DAIRY CATTLE)



(Seminar on Animal Breeding) it was felt that a dynamic and bold approach should be used if we have to meet the challenge of bridging the gap between the availability of milk and its needs in the country. At that time three major drawbacks in our cattle were identified for improvement in the shortest possible time.

1. Slow growth and late maturity.
2. Long calving intervals, long service period and poor reproductive efficiency.
3. Poor yields per unit of time and weight.

It was, therefore, necessary to introduce genes which would improve these three major groups of characteristics in our cattle, while retaining the qualities of disease resistance, hardiness and adaptability to tropical climate.

After making a survey of genetic attributes available in various breeds of cattle around the globe, it was found that Friesians had the fastest growth and largest amount of milk and it was one of the breeds which adapted very well to both temperate and tropical climates.

Brown Swiss is very hardy and a medium producer of butter fat and of medium size. Its American strain is the next highest producer of milk. It has also succeeded in certain tropical areas of Greece where it was tried for imrovement of milk. Jersey is an early maturing high-fat in milk animal, of relatively small size. It is stated that its feed conversion is highly economic. It was felt that genes from these three breeds be introduced in various combinations and be assessed under various agro-climatic conditions. It may eventually give us one, two or several new strains or crosses which can then be rapidly multiplied within the country and by effective use of selection and breeding methodology could be stabilised after five generations as a specific breed/strain/variety.

Since an exact answer could not be given as to which combination would give the best results, twelve different combinations were attempted in the first phase.

Another important factor which was effectively made use of was the introduction as a male parent of frozen germplasm from the best bulls in the Friesian, Brown Swiss or Jersey bull with less than 2000 lb, 11000 lb and 9000 lb daughters average of milk yield in 305 days respectively entered this programme.

Major Cross Breeding Project

A major cross breeding project was initiated during the Fourth Five-Year Plan at five different centres using three different breeds.

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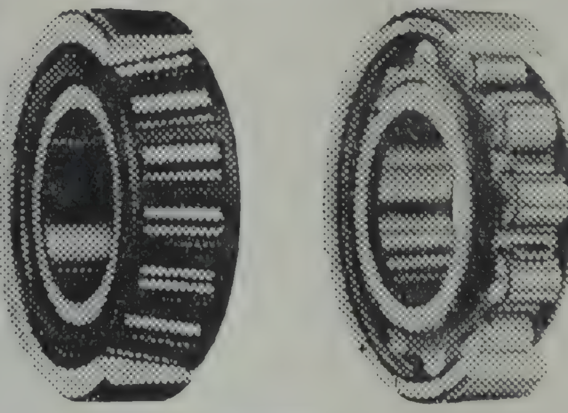

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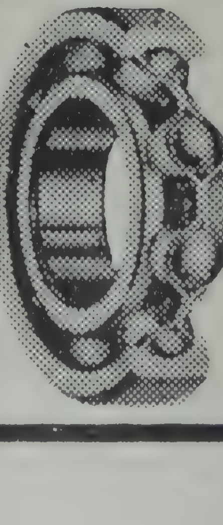

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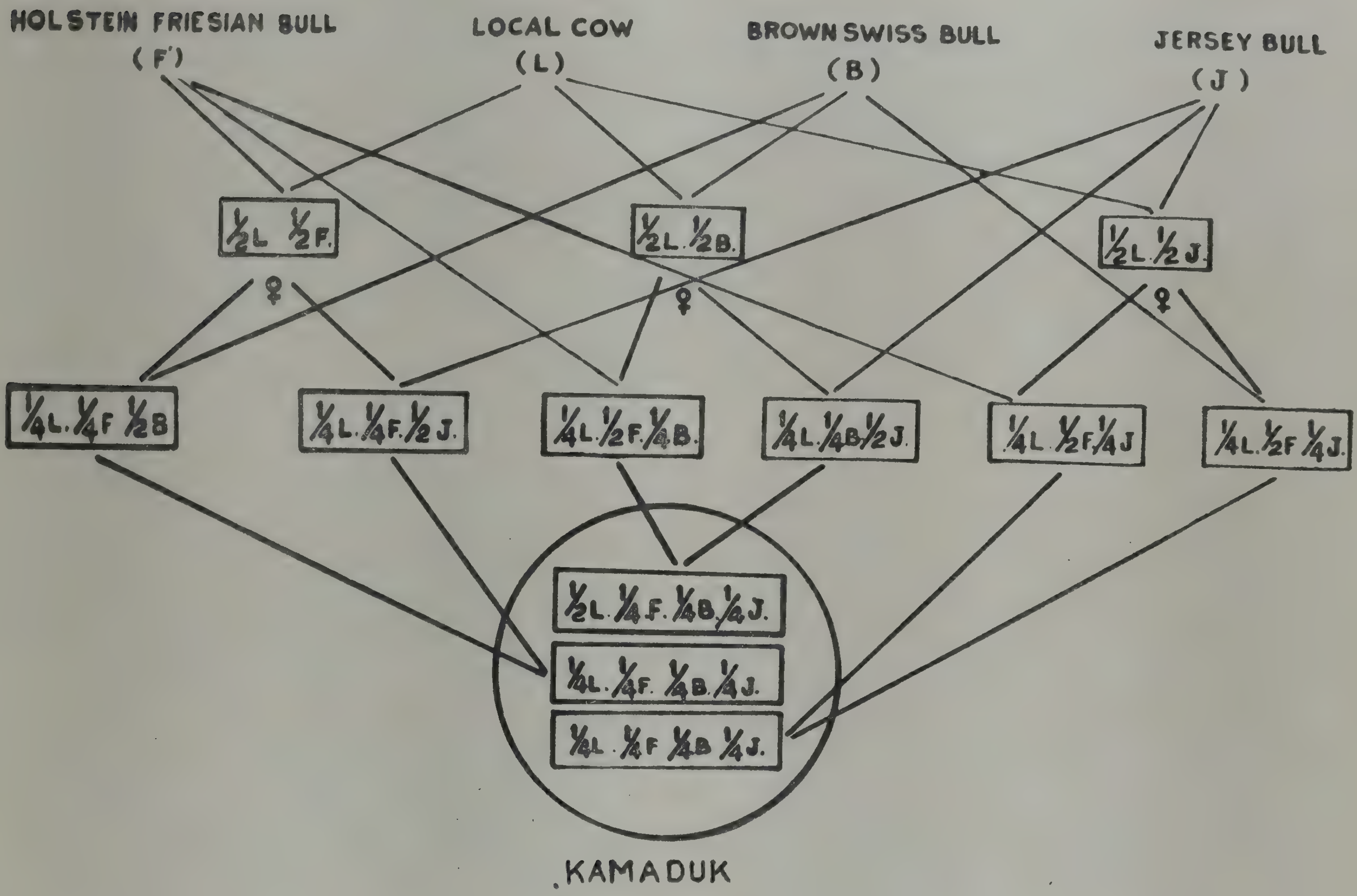
Fig. 2

DIAGRAMATIC REPRESENTATION OF BREEDING PROGRAMME FOR EVOLVING A NEW BREED OF DAIRY COW


HOLSTEIN FRIESIAN BULL
(F')
LOCAL COW
(L)
BROWN SWISS BULL
(B)
JERSEY BULL
(J)
1/2L 1/2F.
♀
1/2L. 1/2B.
♀
1/2L.1/2J.
♀
1/4L.1/4F 1/2B
1/4L.1/4F.1/2 J.
1/4L.1/2F.1/4B.
1/4L.1/4B1/2J.
1/4L 1/2F.1/4J
1/4L.1/2F 1/4J.
1/2L.1/4F.1/4B.1/4J.
1/4L.1/4F. 1/4B.1/4J.
1/4L .1/4F 1/4B 1/4J.
KAMADUK

The breeding programme followed is given in Fig. 1.

As a result of this, cross breeding has been accepted as major factor in the national policy for the improvement of cattle in India. Sizeable progress has so far been made in developing milk pockets in Kerala, Mysore, Andhra Pradesh, Assam and other States.

A critical assessment of the entire thinking in the area of cattle breeding by the author and his students during the past four years has conclusively shown that there is no alternative to us except to produce a new breed of cows which would incorporate all the characteristics present in the three exotic breeds and then blend these with two major characteristics (heat tolerance and disease resistance) in indigenous breeds. It has been shown that if 1/4th of the indigenous inheritance is available the qualities of disease resistance and heat tolerance are maintained at almost the same level at which they are available in the indigenous parent. Therefore, the next difficult question, which is being posed to us, is how to blend these three gene pools of exotic origin into one and generate a scheme of breeding which would have a 3/4th complement of total exotic inheritance equally contributed by all the three breeds. After considerable thinking about this future cow Kamaduk, the cow of plenty, will only be produced in the system of breeding as shown in Fig. 2.

This new cow would have all the characteristics which are available in the Friesian, Brown Swiss and Jersey and will have the two best qualities of their indigenous parent. This future cow would be our mainstay of a flourishing and a prosperous dairy industry.

PROGRESS IN SHEEP PRODUCTION RESEARCH IN INDIA

R.M. ACHARYA and B.C. PATNAYAK
Central Sheep and Wool Research Institute
Avikanagar, via Jaipur (Rajasthan)

INDIA ranks the fifth largest country of the world in sheep population. The projected figures indicate that now there are 46 million sheep in the country and these will increase to 52 million in 1975-76. Likewise, the total wool production in 1971-72 was 0.426 million tonnes and it will increase to 0.495 million tonnes in 1975-76. The projected total mutton production was 0.172 million tonnes in 1971-72 and it will increase to 0.205 million tonnes in 1975-76.

Breeding

Most of the work on improvement of native sheep breeds through selection and through crossbreeding with exotic fine wool and mutton breeds has been undertaken under the I.C.A.R. Scheme 'Improvement of Sheep on Regional Basis' and few other *Ad hoc* schemes.

Selective Breeding

During the pre-independence and immediately post-independence period attempts were made to evolve strains of sheep with uniform non-hairy fleeces of finer quality through selection against medullation percentages. Such a selection has been practised at Sheep Breeding Farm, Poona, Livestock Farm, Hissar, Sheep Breeding Farm, Pattan and Sheep Breeding Farm, Ootacammund. The results indicate improvement in the wool quality as evidenced by reduction in medullation percentage and correlated decrease in average fibre diameter. The results of selective breeding have, however, not been very encouraging and this could possibly be due to small number of breeding animals involved, poor recording performance of data and its proper utilisation in selecting prospective breeders. There have been some reduction in body size, fertility, milk production consequent to selection for wool quality especially in Lohi breed at Livestock Farm, Hissar. This could largely be due to inbreeding resulting from very small number of rams used, rather than as a consequence of selection against medullation percentage.

Crossbreeding

A few attempts at crossbreeding native breeds with exotic fine wool breeds for improving fine wool production in the country have been made. Australian Merinos, Russian Merinos, Spanish Merinos, Rambouillet Polworth, etc. have been used in these crosses. Some fine wool breeds are claimed to have been evolved from these crosses. The examples being the Hissardale, Kashmir Merino, Deccani Merino and Nilgiris. The results on the performance of the crossbreds indicate their superiority in body-weights, survivability, wool yield and wool quality but slightly inferior in fertility. Out of the exotic breeds used in crosses, Rambouillet crosses have performed better. Although there have been an increase in the wool yield and further improvement in wool quality with increase in exotic inheritance, yet the survivability and disease resistance have been decreased with the increase in exotic inheritance. Considering the present results on crossbreeding, it appears that under field conditions exotic inheritance to the level of 50% can be introduced without any serious problems of disease susceptibility and mortality. Most of the work on crossbreeding has involved too few exotic rams and few native ewes. The I.C.A.R. has now initiated two large All India Co-ordinated Research Projects, 'Sheep for Fine Wool' and 'Sheep for Mutton' to evolve fine wool breed(s) through crossing some native breeds with Rambouillet and Russian Merino, having average grease fleece weight of 2.5 kg and of 58's to 64's wool quality and a mutton breed(s) by crossing some of the native breeds with Suffolk and Dorset Down, having average live weight of 30 kg at 6 month of age. These projects have involved adequate number of exotic rams and native ewes to provide numbers in each crosses and its grade to allow statistically valid comparisons. These projects will provide information on the breed cross(es) and the level of exotic inheritance which will meet our goal. The selected crossbred group(s) will be interbred to create new breed(s).

Canary Colouration

Indian wools, particularly those produced by sheep of dry northern region during autumn months show yellow stain of variable intensity. This stain is non-scourable and stained wools cannot be dyed in pastel shades. This yellow stain is referred to as 'Canary colouration'. Nearly 7 to 8 million kg of wool is produced during autumn months in this region and is stained yellow to variable degree and fetch nearly 30 to 40% less price than white wools of similar qualities. This results in a loss of 8 to 10 million rupees per year. Wools of Nali and Chokla breeds are highly canary-stained whereas those of Magra, Marwari, Jaisalmeri, Sonadi, Lohi and Malpura breeds from Rajasthan, Punjab and Haryana exhibit medium to light stain.

In order to investigate into causes responsible for yellowing of wool, the I.C.A.R. had sponsored a coordinated scheme at Sheep Breeding Farm, Jaipur (Rajasthan), Shri Ram Institute of Industrial Research, Delhi and at Central Leather Research Institute, Madras. At Jaipur, field investigations were carried out on yellow colouration of the wool whereas in other two laboratories chemical investigations were undertaken. The results obtained so far are variable and conflicting. The causes attributed for development of this condition is the alkaline suint, hot and humid climate, nutrition, heredity, micro-organisms, damage of wool fibre and entrance of a pigment into it causing yellowness. The literature is much in favour of the concept that development of yellow stain is mostly due to the action of alkaline suint produced during the hot and humid weather. The alkalinity damages the wool fibre and the pigment, probably secreted from the sweat gland, enters into the damaged fibre. This concept is favoured by experimental finding that there is a greater positive correlation between the yellow stain and very high suint-grease ratio of the wool. At the Shri Ram Institute, attempts have been made to isolate and characterize the suint pigment. It has been found that the isolated pigment is of porphyrin type and could be related to any of the body pigments containing porphyrin ring.

Recently, the I.C.A.R. has sponsored a Coordinated Project with centres at C.S.W.R.I., Avikanagar Rajasthan; Veterinary College, Bikaner and Wool Research Association at Bombay. The scientists at the C.S.W.R.I. centre are carrying out research on genetic, environmental, managemental, nutritional and other biochemical factors involved in the causation of canary colour and genetic, nutrition and management methods of eliminating the colouration. The scientists at Bikaner centre are carrying out work on microbiological factors and trace elements involved in this complicated bio-process. The work on mechano-chemical properties of the wool, isolation and further characterisation of the suint pigment, etc. are being carried out by scientists at Wool Research Association, Bombay. Experiments to study the manufacturing aspects of canary coloured wools on different systems has been undertaken at C.S.W.R.I. It is hoped that in the next few years to come, more concrete research on this complicated problem will be available and possible approaches towards its solution will help in reducing heavy economic losses.

Nutrition

Very little attention has been paid towards research on sheep nutrition in India. It is a well known fact that inadequate nutrition and traditional practices of management are the important factors responsible for heavy mortality and morbidity resulting in poor growth and low reproductive and productive efficiency of our sheep. Considering the annual national income from sheep and their products such as wool, mutton, manure, skins, etc., and that a great majority of farming population in arid and semi-arid areas depends on sheep farming, proper feeding of sheep and their management are of great importance.

Sheep nutrition in India poses a peculiar problem because of the fact that majority of the sheep flocks in northern and north-western region of the country are migratory and also they are owned by poor and most backward farmers. Furthermore, sheep nutrition was not recognised by the scientific community in the country until its importance was felt when there were increased imports of exotic fine wool, mutton or dual purpose breeds. Although sheep can thrive well on forages alone than any other kind of livestock, the forages available for our sheep under natural conditions do not provide sufficient nutrients required. Very little attention was paid to develop improved pastures or to improve the available vast lands and grazing areas in the country. Only recently work has been initiated on pasture development and management, evaluation of common feeds, fodders, tree leaves, shrubs and bushes consumed by sheep and nutritive requirements for various productive purposes of sheep.

Nutritive evaluation studies

As a first step in nutrition research for sheep,

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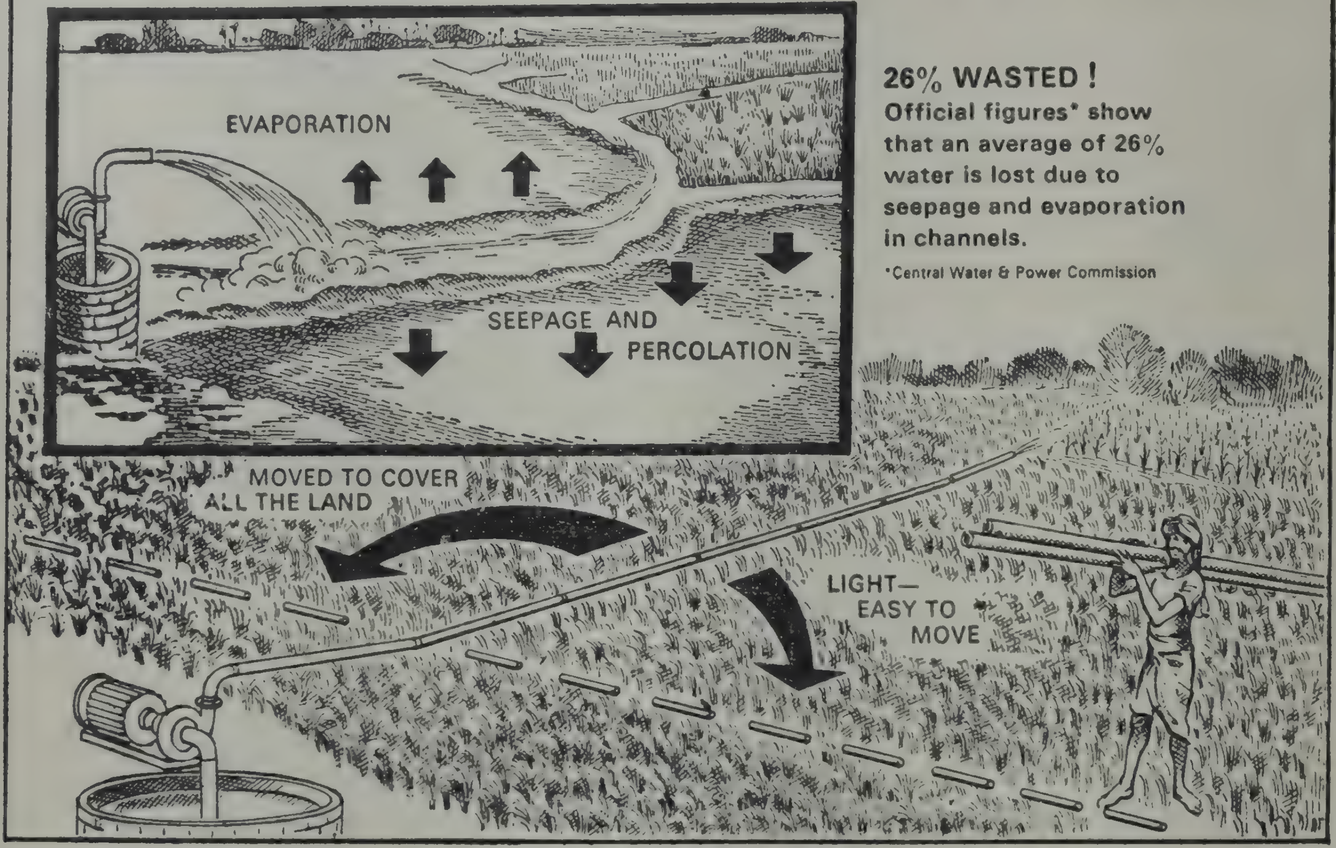

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studies have been undertaken to evaluate the common feeds and fodders available in local areas. The feeding values for spentleman grass, coffee husk, tamarind husk, jack seeds and leaves, cotton seeds, rubber seeds, Kaina and tapioca leaves were worked out at Kerala Veterinary College. At College of Veterinary Science, Bikaner, studies on the nutritional value of some of the naturally growing feeds and fodders in Bikaner area were undertaken. These studies included evaluation of Makra, Ganthia, Bhurat Bur, Lamp, Pala and Loong. Palatability was higher for Loong, Pala and Makra and growth rate of sheep fed on these fodders was also higher. Wool yield from sheep fed Makra was higher than from those fed Ganthia, Loong and Pala. Studies on evaluation of certain shrubs and tree leaves consumed by sheep was taken up at C.S.W.R.I. Avikanagar by Nath and co-workers. The fodders evaluated were Pala, Gokhru and Bekaria. Pala leaves were rich in crude protein (14%) but the protein available was poorly digestible. Gokhru was highly palatable in post-flowering stage and contained 9% digestible crude protein, Bekaria leaves were also found to be palatable for sheep and an average consumption of 4.4 kg per 100 kg body-weight was reported for Malpura sheep. Many of the grasses studied for their nutritive value in sheep are Kikuyu, Hirankuri, Baru, Sewan, Makra and Doob by workers at Mathura Veterinary College.

Nutritional Requirement Studies

Very little work has been done on nutritive requirements for various categories of sheep. At livestock farm Hissar, better performance was obtained by providing 225 to 450 g of grain mixture in addition to grazing. Sharma and Kidwai (1971) reported that supplementation of 100 g of decorticated groundnut cake in addition to grazing plus feeding of 117 g of concentrate mixture resulted in better performance of male lambs. Feed lot experiments were conducted at Haryana Agril. University, Hissar by Balaine *et al*, (1971) with Nali, Lohi, Nellore × Lohi, Nellore × Nali and Mandya × Nali lambs following weaning. Although Lohi gained faster than Nali or the crosses of these two with Nellore and Mandya, the efficiency of feed conversion of this group was lower than Nali. Weight gain in Nali lambs was faster than the three crosses. At the C.S.W.R.I., Avikanagar, a series of experiments have been conducted to determine the requirements of supplementary feeding for growing weaner lambs. Supplementation of 550 g of concentrate mixture to weaner lambs, in addition to grazing could increase the carcass yield by about 55%, whereas, supplementation of about 400 g of concentrate mixture would result in an increase of carcass yield by about 30%. There was very little difference between the liveweight gains and carcass weights obtained with supplementation of 200 g of concentrate mixture or about 200 g of cowpea hay. In another experiment it was observed that after grazing, lambs of about 7 months of age could consume approximately 400 g of cowpea or guar hay and both cowpea and guar hay produced similar weight gains.

Feed additives and antibiotics

Studies have also been undertaken on feeding of antibiotics to sheep. Ram Prakash and Mahal (1961) observed that by feeding 2 mg of antibiotics (aureomycin, penicillin and streptomycin) to lambs, the average daily growth rate was significantly greater than the control group. In another study, Chorey *et al.* (1965) did not observe any significant change in the growth rate of lambs fed Oxytetracycline at the rate of 20 mg per day. Kaduskar (1965) studied the effect of a commercial preparation of fungal and bacterial enzymes on the growth rate of lambs and found no beneficial effect.

Pachauri (1970) administered diethlylstilboesterol (pellets) to adult sheep at the rate of 2.5, 5 and 10 mg per day/sheep and found no difference either in digestibility of the proximate principles or in the balances of nitrogen, calcium and phosphorus. Much more work on feeding of antibiotics, hormones and other growth stimulators need be done with growing lambs for economic feasibility under field application.

Reproduction and artificial insemination

Although appropriate breeding and feeding constitute important aspects of scientific management of livestock, proper control of reproductive processes and the related husbandry practices are important for profitable livestock farming. Total flock productivity depends on the fertility, percentage lambing, survival rate, growth, wool yield and its quality. There should be high fertility and lambing rates and a low mortality rate. Although sheep in greater part of this country breed throughout the year, there are certain more optimum breeding seasons with respect to fertility and later lamb survival and growth.

Optimum breeding season

Little work on determining optimum breeding season in different agro-climatic regions of the country has been undertaken. It is important that sheep are bred at the appropriate time during a minimum length of breeding season so that the length of lambing season is reduced which in turn will facilitate care, management and marketing of lambs. Roy and co-workers working at Veterinary College, Mathura, reported that Bikaneri sheep are non-seasonal in their sexual activity. Eighty to 90 per cent of the ewes came in heat within a period of 20 to 30 days after the introduction of vasectomized rams, whereas about 10 per cent of ewes came in heat after 30—50 days. They further reported that Bikaneri sheep (Magra) are non-seasonal in sexual activity and can be bred in any season of the year with equal success. It was suggested that in a period of two years three lamb crops can be obtained from the same flock if good management practices are followed.

Although sheep in north-western India breed throughout the year, there are two naturally occurring peak breeding seasons—one during May and June and the other during October and November. Breeding season is from middle of March to April and occasionally up to May and the other from August to end of October has been observed in Southern breeds.

Tyagi and Lavania (1968) also studied the breeding season of indigenous, half Polworth and 3/4th Polworth crossbred sheep. Monthly mean temperature was found to influence the breeding season of the indigenous ewes, but its effect was lesser in crossbred ewes than the former. A relationship was also found between monthly mean bright sunshine hours and occurrence of oestrus. Monsoon, autumn and early winters were the breeding seasons. It has also been reported that breeding season in sheep of U.P. Hills is associated with declining photoperiod, with peak activity restricted to autumn months, the maximum lambing activity seemed to be restricted to December and January (Purohit, 1968).

Breeding season in sheep has the practical significance because of its relationship with lambing season which, in turn, influences lamb mortality. Malik (1966) observed that lambing season for Magra sheep was from January to March (1970). At Haryana Agril. University lambing seasons for Nali and Lohi sheep and their crosses with Nellore and Mandya were in February-March and in September-October. In the same lambing season lambs born earlier survived better as compared to those born later. The average birth weight of lambs which did not survive was lower than those which survived.

Synchronisation of oestrus

Lambing season can be controlled by regulating breeding season of ewes through a hormonal method of bringing the ewes in heat simultaneously or during a limited period. (Synchronisation of oestrus). Honmode (1968) at C.S.W.R.I. worked on hormonal synchronization of oestrus in Malpura ewes. During the breeding season of September-October, groups of ewes were treated with different hormone preparations and their combinations. The effect of a progesterone preparation (MAP) in combination with stillbesterol was found to be more effective than others administered individually for achieving oestrus synchronization. Dhanda (1970) at Haryana Agril. University also attempted to synchronize the oestrus of Nali ewes by treatment of progesterone and oestrogen hormones. Both of them were found effective in suppressing the ovarian activity of the ewes. 87% of the progesterone treated ewes exhibited oestrus within 72 hours after cessation of the treatment, whereas only 13 per cent of oestrogen treated ewes exhibited heat. No serious side effects were observed in the ewes treated with progesterone whereas oestrogen treatment caused cystic condition of the ovaries. From these studies it would appear that progesterone could be effectively employed for synchronising the oestrus in sheep. Although it has been found effective in experimental situations, its field application and its economic feasibility is still awaited.

Semen dilution, preservation and artificial insemination

Ram fertility is also considered very important for profitable sheep production. Due to lack of sufficient number of proven rams, artificial insemination has also been resorted to in sheep. For this purpose attempts have been made to develop suitable dilutors for extending and preserving ram semen. Roy and co-workers at Veterinary College, Mathura, reported that motility and survival time of spermatozoa was much better in egg-yolk-glycine dilutor. In further investigations on ram semen dilutors, maximum survival (ten times) of the spermatozoa was observed with Cornell University extender (CUE) and cow milk dilutors. The sperm motility after 6 and 54 hours of storage in these dilutors at 5°C were found to be 70—80 and 45—50 per cent respectively. The motility was reduced to 20—30% on the 6th day and there was little influence of season on the spermatozoal survival. Semen quality deteriorated when it was diluted beyond 1:30. Semen of optimum quality fit for artificial insemination could be collected in any part of the year from rams of native breeds.

Deep-freezing of semen

In order to successfully deep-freeze the semen, detailed information on the physical, chemical and biochemical parameters of the semen and their relation to fertility are essential. Attempts are being made to produce deep froze ram semen. Some amount of work has been done in this direction and the work is also in progress at C.S.W.R.I., Avikanagar.

Ram fertility

Work on predicting fertility from libido and semen characteristics and on genetic aspects of fertility has been carried out at Haryana Agril. University by Acharya and his students. Consistency, motility, pH, normal live percentage, and percentage dead sperms were significantly related to fertility in rams. The multiple correlation with fertility (lambing percentage) was 0.436 (Dhillion, 1970).

Semen Biochemistry

Pareek et al., (1969) reported that semen lactic acid content had a positive and highly significant correlation with volume of ejaculate and also it had a positive, but no-significant correlation with initial sperm motility, pH and sperm concentration. Semen lactic acid was higher in winters. At Haryana Agril. University workers observed that the concentration of alkaline and acid phosphatase were significantly higher in Nali as compared to Lohi semen. The opposite was, however, true for total reducing sugars and fructose contents. It was also observed that the concentration of semen plasma proteins was little higher in Nali as compared to Lohi ram seminal plasma.

Preliminary work carried out at C.S.W.R.I. did not show any significant differences in various physical and biochemical attributes on the semen of local and crossbred rams.

More work on the biochemical aspects of ram semen especially for evolving suitable dilution and preservation techniques is required.

Health

Sheep suffer from a number of diseases of both contagious and non-contagious nature. Overstocking, grazing on low and wet lands, sudden changes in environment and feed are some of the main pre-disposing causes of sickness in sheep. Due to the flocking nature of this species, immediate attention is needed at the onset of the disease to check spread of disease and mortality in the flock.

Parasitic diseases

The most common internal parasites in sheep include liver fluke, gastro-intestinal and respiratory parasites. In addition to these internal parasites, certain external parasites such as ticks, mite and lice, are also common. A survey conducted in Gujarat has shown that 15% of deaths among sheep are caused by parasitic gastro-enteritis.

Several drugs have been shown to be very effective in control of gastro-intestinal parasites in sheep. Thiobenzole has been very effective for this purpose. Workers at C.S.W.R.I. reported excellent results at the dose rate of 50 mg/kg body-weight. The treated sheep showed an increase in live-weight of 0.5 to 5.5 kg whereas the untreated sheep lost 1 to 6.5 kg during a period of two months. Nilverm (Tetramisole) was also tried for treatment of gastro-intestinal nematodiasis. The drug at the dose rate of 10 ml/15—25 kg body-weight and 15 ml/25—35 kg body-weight has been found to be very effective. The treated sheep showed three times increase in weight over the controls. Many workers have studied the resistance of worms to temperature and humidity. Oesophagotomum species survived longer at low temperature and high relative humidity. The survival rates fell with increase in temperature and this was specially marked when accompanied by lower humidities, sheep develop acquired immunity or innate resistance to helminth parasites. Administration of cortisone at the dose rate of 50 and 25 mg/kg body-weight daily to lambs for a period of 10 days resulted in breakdown of resistance of lambs to O. columbianum infection.

Workers at C.S.W.R.I. observed a breed susceptibility for helminthic infection. Malpura and Rambouillet × Malpura crossbreds were found to be better tolerant to heavy infection whereas Rambouillet and Rambouillet × Chokla crossbreds sustained heavy losses due to the infection.

Bacterial diseases

The most common bacterial diseases in sheep are Pneumonia, enterotoxaemia, foot rot, struck, black disease, haemorrhagic septecaemia, salmonellosis. Other bacterial diseases of relatively low incidence in Indian sheep are Johne's disease, lamb dysentery, listeriosis, leptosprirosis, brucellosis and tuberculosis.

Pneumonia constitutes one of the major causes of mortality in sheep both as a primary and a secondary infection, Minnet (1950) reported that mortality in sheep due to pneumonia was 21, 14, 11, 13, 6 and 7 per cent for first six years of age. Ramachandran (1959) reported that the incidence of sheep pneumonia was seasonal in distribution and a large majority occured during the months of August, September and October. Data for 2 to 6 years at several sheep breeding farms in Jammu and Kashmir also showed that deaths due to pneumonia tended to be seasonal in distribution being highest during April-June, when 47% of the total deaths occurred, (Kaw and Khera, 1970). Although the exact aetiology of the condition is unknown, a variety of micro-organisms have been incriminated for the disease. Misra *et al.* (1971), performed bacteriological examinations of morbid materials from cases of pneumonia received from eleven states during the period 1959—1968. 46% of the total morbid specimen were received during March, April, May and December. The isolates belonged to over 25 bacterial species of pathogenic significance. Raghavan and D'Souza (1971), reported that there was no difference in bacterial flora of normal and diseased sheep lung. The disease did not suggest a viral aetiology. There was a highly significant correlation between pneumonic condition and helminthic parasite level. Suppurative pneumonia is of frequent occurrence. Chattopadhyay *et al.*, (1971) studied the incidence and pathology of this disease in the flocks at C.S.W.R.I., Avikanagar. 15%

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of the total mortality was due to this disease and 45% of pneumonia cases were suppurative pneumonia. Mortality was more in adults than in lambs and in exotic breeds, particularly the Rambouillet more than the natives and cross-breds. Maximum extreme that is in dry summer and winter months. In addition to suppurative pneumonia, pulmonary oedema, interstitial pneumonia and grey hepatisation were observed.

Viral diseases

Sheep pox, foot and mouth, ecthyma, and pustular dermatitis are of frequent occurrences. Sheep pox is of very common occurrence. It was reported from Punjab that vaccination by applying vesicular pulp from the affected cases produce fairly good grade immunity against the disease. The procedure was called ovination. Extensive work at I.V.R.I. has been carried out to develop a vaccine against this disease complement fixation and the agglutinating complement absorption tests were found to be convenient tools to assess the antibody level in the sera of sheep infected with sheep pox virus. The latter test was found responsible for spread of the disease to susceptible animals and also for production of untoward reactions in the vaccinated animals. Sharma and Dhanda (1970b) carried out immunization trials with live as well as inactivated vaccines. The inactivated adjuvant vaccine has now been put to field use at C.S.W.R.I., Avikanagar by the technical experts from I.V.R.I. Mukteswar, U.P.

Summary and Conclusions

Work on improvement of native sheep breeds through selection and through crossbreeding with exotic fine wool and mutton breeds has been undertaken on regional basis. Selection against medullation percentage with a view to evolving strains of sheep with uniform non-hairy fleeces of finer quality has been successful in reducing medullation percentage and fibre diameter. However, in some cases there have been a little progress and in others there has been consequent decrease in both size, fertility, milk production, etc. Selection in mutton breeds has not given encouraging results. The lack of improvement through selection could possibly be due to small numbers of breeding animals, poor recording of performance data and its utilisation in selecting prospective breeders. Crossbreeding with fine wool breeds has shown that crossbreds in general are superior in body-weights, survivability, wool yield and wool quality and only slightly inferior in fertility, compared to the native breeds involved in the crosses. Out of the exotic breeds Rambouillet has produced beter crossbreds with the native breeds. There has been improvement in body size, wool yield and wool quality with increase in exotic inheritance beyond 50% but the survivability and disease resistance has been lowered. It appears that under the present conditions of nutrition and management, the level of exotic inheritance which can be safely introduced under field conditions should not exceed 50%.

Work on evaluation of natural grasses common bushes and shrubs consumed by sheep, some tree leaves relished by sheep and on some cultivable cereal and legume fodders has been done. It has been observed, that, in general, adult sheep fed grasses alone or maintained on the pasture alone, could barely maintain their body-weight. These grasses were found to be low in protein and phosphorus. It is necessary to carry out intensive research on a limited number of grasses commonly available in the various agro-climatic regions and ways of improving them for large scale application. Very little work has been done on the nutritive requirements of the Indian sheep for growth, pregnancy, lactation and wool production. Some work done relating to this area is only on requirement of supplementary feeding. More systematic and detailed studies need to be undertaken on the requirements for energy, protein, minerals and vitamins for different types of sheep in different physiological states and to find out more suitable ways to meet these requirements from the available resources. Sheep being mainly dependent on pasture, greater emphasis has to be given to develop permanent pasture on the vast areas of uncultivable land in the arid and semi-arid areas of the country. The natural pastures are generally low in protein and should be treated with nitrogenous fertilizers or perennial legumes should be introduced into them improving their quality. Work has been initiated to provide supplementary non-protein nitrogen to the grazing sheep through licks and in water. The work in this area needs to be intensified. The practice of preservation of fodder to be used during scarcity periods (summer in arid and semi-erid areas and winter in temperate areas) has to be encouraged. Very little work has been done on use of certain feed additives, antibiotics, hormones and other growth stimulators and their use has not found any field application. More extensive work should be done in a systematic and sustained manner to give concrete recommendations for their commercial application more particularly for fat lamb production. Detailed studies on mineral nutrition in relation to growth and wool production have to be taken up keeping in view the field problems and their possible application.

Limited amount of work has been done to determine optimum breeding season of the indigenous breeds of ewes. Although most of Indian sheep breed throughout the year, two peak seasons have been observed in some areas of the country. More work should be carried out on regional basis to determine the optimum breeding season in terms of maximum ewe fertility, and survival rate and growth in lambs. Work on artificial insemination in sheep has been taken up mainly at Mathura and C.S.W.R.I. This method needs to be further perfected for use in most of the sheep raising areas of the country. Already some work has been done on finding out suitable ram semen diluents at Veterinary College at Mathura, C.S.W.R.I. and I.V.R.I. Cow-milk diluent has already found its field application. However, the keeping quality of semen in this diluent is low. More work on semen dilution and preservation techniques and their effect on fertility should be done. Work already initiated on semen biochemistry should be intensified for correlating certain biochemical parameters with semen preservability and fertility. Attempts on preparation of frozen ram semen have not been successful. Consistent effort should be made in this direction which is of great use in the application of artificial insemination in sheep. Although some work has been done in oestrus synchronisation with success, its feasibility under field conditions and its economics need to be worked out. Attempts have to be made for causing multiple ovulation and increasing twinning rate.

For programmes for augmenting production to be successful, effective measures have to be taken for disease control. Already methods have been developed to control parasitic diseases, more particularly gastro-intestinal parasites by drenching with thiabenzole and Nilverm. Effective vaccines against certain bacterial and viral diseases like haemorrhagic septicaemia, enterotoxaemia, sheep pox, etc. have been developed. There should be more extensive field application of these vaccines. Causes and control of pneumonia in sheep which is an important cause of mortality have still not been effectively investigated. More extensive research on the diagnosis and prophylatics of important sheep diseases need to be undertaken.

Statistical and economic survey have been carried out on a limited scale. Based on the data available from these surveys it has been seen that annual income of a farmer with a flock of 100 breeding ewes, a few rams and their followers would be Rs 3,881 and Rs 5642 for Chokla and Nali respectively.

Acknowledgement

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Ganga 5, the new maize from the experimental fields of I.A.R.I., New Delhi.

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TRYST WITH AGRICULTURAL DESTINY IV

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Editor's page

A Breakthrough in Sight?

THOUGH the scientists at the headquarters would be monitoring every development, for us in *Indian Farming,* the antenna bristles at every written word on the dry belt, whatever the source. According to an erudite writer in one of the distinguished contemporaries in the Capital, there is a distinct breakthrough in dry farming. The conclusion is based on crops produced —the final arbiter in agricultural research.

At Hayatnagar near Hyderabad, the workers of the Dry Farming Project have succeeded in producing 300 per cent higher yield than of a normal season, while the entire kharif crop miles around has been ravaged by a severe drought. The sight was attracting hundreds of incredulous farmers. In the farm were sturdy rows of jowar, bajra, fox-tail millets, dolichos beans, arhar, moong, lobia, sunflower, safflower and castor.

How was it done?

There is an elemental simplicity about the technique. According to the Project Director, as conveyed to the investigator, there are three cardinal points: the use of fertilizers, precision sowing, and the rigorous elimination of weeds. The fertilizers perform a vital 'underground' job. "They promote a vigorous growth of roots, enabling fertilized plants to tap deeper layers of moisture that are altogether beyond the reach of an unfertilized crop. It is this ability to burrow into the ground in search of water that enables them to survive for more than twice as long as they would otherwise have done". Next, root out the weeds, the voracious consumer of water. And then the farmer has to take care that there are just the right number of plants to derive the maximum return on the money invested on fertilizers.

At ICRISAT (International Crop Research Institute for Semi-arid Tropics) in Hyderabad, Dr Bert Krantz has adopted a different strategy but with equally surprising results. The answer is just one inch of extra water. Cultivate part of the holding and treat the rest of the holding as a mini-catchment area. And apply this extra inch of water *precisely* when the plants are *thirstiest.* ICRISAT has successfully demonstrated that "this extra inch of water applied at the right time, together with a combination of other appropriate agronomic practices can jack up jowar yields by ten times the national average".

To us another important finding is yet to come and that is in relation to the personnel required. "For an elaborate system of the kind that has worked successfully in Ibrahimpatnam (one of the extension areas of the project) . . . it requires one Chief Project Officer, four graduate specialists, seven matriculate sub-assistants, one accountant, three junior clerks, one driver, two peons and an annual expenditure of over Rs. 20 lakhs to mobilise 400 farmers in three villages with a total cultivated area of only 8000 acres".

Now read our editorial in the September 1972 issue. Was there any vague generalisation when we advocated the positioning of all our Ph.D.s., all our M.Sc.s, all our B.Sc.s in the dry belt of India for a mammoth post-independence crusade for changing the destiny of the poverty belt ?

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PLANNING FOR MORE PRODUCTIVE CULTIVATION

H. R. ARAKERI

Member, National Commission on Agriculture, New Delhi

INDIA is one of the most populated countries in the world; it has 20 per cent of the population with 2.5 per cent of geographical area. India's population may reach 1,000 million mark by the end of the century if the present trend of increase continues. The problem is further accentuated because economy is continuing to be largely agrarian with 70 per cent of economically active population depending on agriculture as against less than 10 per cent in western countries and about 17 per cent in Japan. It is necessary to plan for the optimum use of the limited land resources of the country if productivity is to be substantially raised. There is scope for bringing about improvement in the patterns of cropping as well as in the cultivation plan of each crop.

The objectives in planning will have to include domestic needs including import substitution and products for export market. In India, welfare is an important consideration from the point of view of income distribution or redistribution amongst social classes or regions. Welfare consideration and employment are very closely linked. Participation by the rural people in the production process and in the distribution of income generated is possible only when employment opportunities are provided for them. Conservation of natural resources is also an important consideration. In short, goals will have to be:

(1) To meet the needs of the country for (i) domestic use, (ii) import substitution, and (iii) exports;

(2) To provide for meeting the welfare objectives of (i) employment, (ii) income distribution, and (iii) conservation of natural resources.

Setting targets for achieving the first objective usually does not present special difficulties. The other problem is a more complicated one. It is not proposed to discuss all these aspects here. It is proposed to cover mainly the possibilities of changing the cropping patterns in various regions in the country.

Planning will have to be regionwise. The country can be divided into regions on the basis of climate, soils, crops, etc. Water is the most important factor that decides cropping patterns. To simplify matters, we can divide the country into three regions according to intensity of rainfall, i.e. heavy rainfall, low rainfall and medium rainfall. The total area under various intensities of rainfall are as follows:

	Net area sown	*Gross area sown*
	(million hectares)	
1. Very high and high rainfall 1150 mm and above	41.5	49.6
2. Medium rainfall 750-1150 mm	49.2	57.4
3. Low rainfall below 750 mm	46.8	51.6

Cropping Patterns

Existing cropping patterns and possibilities of changing the same in these regions are discussed:

Heavy Rainfall Regions. The most dominating crops in heavy rainfall regions, as expected, are paddy and plantation crops. Probably, there is not much scope for changing cropping patterns because very few crops can be grown under heavy rainfall conditions. There is, however, some scope for introducing new plantation crops. While it may be difficult to replace paddy in low-lying areas, it should not be very difficult to grow forage crops on sloping and high-lying lands. We have not given much attention to the introduction and development of forage crops in heavy rainfall areas. There is no doubt that information on forage crops, suited to tropical and heavy rainfall area, is meagre. More research is needed not only on introducing new kinds and varieties, but also on other aspects of production. Grasses and trees are found everywhere in heavy rainfall areas, but not nutritious fodder for cattle. Heavy rainfall areas are known for dwarf and sickly looking animals. It is in these heavy rainfall areas that large herds of unproductive cattle are maintained just for 'manure' purpose. The soil is low in bone building elements like calcium and phosphorus. It is low in other nutrients too. As a result, forage material is low in nutritive value. Paddy straw that is commonly used for feeding animals does not provide the needed nutrition. The urgent need of this area is to provide nutritious food through better crops and varieties that are nourished properly and through well-fed animals and birds. In these areas, no doubt, there are more problems of pests and diseases. Post-harvest problems also are critical and need appropriate solution.

In the areas which get rainfall prior to and after the regular season, there is possibility of taking two crops. In such areas, there are better chances of introducing a variety of crops before or after paddy. In some areas, there are possibilities of developing water resources for supplemental irrigation. Where such facilities are evident, introduction of forage crops, pulses, vegetables, etc., after or before the main crop in suitable areas would be a great advantage not only for supplying nutritious food and feed for human and animal population respectively, but also for providing increased employment opportunities in these areas and successfully breaking the linkage between paddy and poverty.

Low Rainfall Regions. Areas that get 500 mm of rainfall are difficult areas in many ways. Rainfall is uncertain in quantity and distribution. Season's total rainfall may occur just in two or three days and it may occur early or late in the season. Total quantity also varies considerably from year to year. With such uncertainties, adoption of any cropping plan with certainty is a challenging task. It is, therefore, necessary to provide for alternative cropping plans. When there is no definiteness about the existing cropping patterns in vogue today, the possibilities of changing them may also look bleak. While there are tremendous possibilities of increasing the yields per acre of commonly grown crops by adopting better soil and water conservation measures and agronomic practices, there is scope for introducing new crops and cropping patterns also with advantage. The scope can be further improved if measures are taken to improve water resources for supplemental irrigation by adopting farm pond and water harvest techniques. In these areas, there is scope for tapping underground water resources also. With the introduction of short-duration, drought-resistant, high-yielding hybrids of jowar, bajra and varieties of castor, sunflower, etc. prospects of improving the economic situation in these areas have become brighter.

The aspect that has not been looked into is the possibility of introducing animal husbandry and forestry. The possibilities of introducing forage crops in rotation with other crops have not been examined in depth. So far, attempts have been made to grow forage crops in exclusive areas. It is advisable to put shallow and eroded or erodable patches permanently to grasses or legumes. Growing of trees that yield forage material and other economic products may become a paying proposition in the long run rather than growing arable crops as done at present by gambling with erratic rains. Sheep rearing both for wool and mutton is a distinct possibility. Slopes should be covered with grasses and sprinkling of trees both from national land resources point of view as well as economic point of view. Such possibilities do exist in the dry regions. They are required to be examined in detail and studied further from all points of view. In areas where the rainfall extends for a longer period, there is a possibility of taking two crops by introducing short-duration varieties. This has become possible in some areas where hybrid jowar has been introduced in place of traditional variety of jowar which is of longer duration.

The areas receiving more than 500 mm rainfall offer better opportunities for diversification. But exact recommendations are wanting.

Transitional Belt. This is a belt which is between heavy rainfall areas and low rainfall areas. It is difficult to demarcate this belt in a clear-cut manner. The change-over from heavy rainfall to low rainfall takes place gradually. It is in this belt, especially in those areas which are adjacent to heavy rainfall belt, that there is considerable scope for introducing better cropping patterns. In this belt, drilled or broadcast paddy is being grown. Rainfall is not sufficient for transplanting except probably in very low lying areas. Rains may fail during any part of the growing period especially during flowering period. Yields are low and vary considerably from year to year. Problem of water shortages is attempted to be solved by providing tanks wherever possible to store and supply water for irrigation during critical periods. These tanks are now silted up and are not serving very useful purpose. The problem of weeds in drilled paddy areas is a formidable one.

Vast areas of this kind are discernible in eastern regions in Bihar, Orissa, West Bengal and in the western region in Mysore, Maharashtra and Gujarat. Maize can be introduced with great success in these areas except in very low lying areas which are likely to get waterlogged. Soyabean is another crop that can find a place in this region. Suitable variety of cotton or tobacco can fit in rotation. All these crops have been successfully introduced in Mysore State, where, as high as 25 quintals of maize per acre are being obtained on an average over large areas. Similarly, yields of Sea Island cotton and tobacco are observed to be high. Soyabean is yet to be tried on a large scale.

This region is very well suited for vegetable and fruit crop cultivation. Animal husbandry can be a successful proposition. For successful introduction of such new enterprises, prerequisite is proper infrastructure including transport, processing, storage and marketing facilities. These areas which are considerably backward at present can be developed into flourishing agricultural regions by systematic introduction of new cropping patterns and by building up the needed infrastructure.

Other half of the belt which is close to drier region, however, is considerably developed. Rainfall is assured and high yields of a variety of crops are obtained. In some areas, double cropping is a common feature. There is scope for improving cropping patterns by introducing multiple, mixed or relay cropping practices and also by developing and introducing early maturing crops. Although standard of cultivation is already high in these regions, there is great scope for devloping and introducing better agronomic and better pest and disease control measures.

Irrigated Areas. Possibilities of changing cropping patterns are more fascinating in the areas with irrigation facilities. Irrigated areas can be divided into four classes according to availability of assured supply of water. In some areas, water is available in plenty for almost the whole year; in some it is available only for 8-9 months and in some others it is available for one season of about 5 months. There are some areas where water is available only for 3-4 months and that too not very certain when it would be available. Rethinking is required to be done as to how the available water resources can be best utilised by working out judicious combination of flow water with underground water on the one hand and irrigation water through different sources with rain water on the other. Various cropping patterns can be worked out by taking irrigation water as supplement to rainwater and vice-versa in all these regions. Main aim should be to make best use of available water resources. All conceivable patterns of multiple, mixed and relay croppings can be tried and profitable ones recommended for adoption. In some of the areas where mainly tank water is available, only for a few months, cropping pattern with hybrid jowar, ratooning of hybrid jowar followed by wheat and soyabean can be recommended in place of paddy. Instead of one long duration crop under irrigation where assured supply of water is available for 5-6 months by introducing early varieties of paddy and by growing seedlings elsewhere, two crops of paddy can be attempted. Various such innovations are possible in different regions depending upon the season and spread of rainfall vis-a-vis the availability and dependability of irrigation water from different sources.

Cropping patterns have been tried so far either for irrigated areas or under rainfed conditions independently. Attempts have not been made to include forage crops or vegetables with a view to developing suitable and more economical mixed farming patterns. The needs of the country are changing. Suitable mixed farming patterns have to be developed for different regions.

Planning for productive cultivation of each crop included in the pattern is another aspect which has to be examined from a different angle altogether. The crop itself and the practices adopted to raise that crop will have tremendous effect on the crop that follows. Studies carried out so far do not include this aspect of the problem. Results of some rotational studies are available. Innumerable experiments have been conducted to work out the agronomic requirements of different crops in different regions. Which crop in the rotation should be given deep tillage, which should receive farmyard manure or compost and which should receive fertilizers and of what kinds are the issues that are required to be studied in totality. The requirements of cropping pattern as a whole will have to be worked out. Farm management and economic aspects of the pattern will also have to be studied and compared. The important aspects that should be looked into are with regard to deep tillage requirements, cumulative effect of application of various kinds of fertilizers and the role of farmyard manure or compost in maintaining the productivity of soil. The pest and disease problem also is required to be kept in mind.

There are some long-range experiments in progress on some farms in the country. The available data should be very carefully analysed and interpreted. Further series of experiments will have to be initiated to know the answers to various questions so that it will be possible to offer to farmers various farm plans along with package of practices to be adopted for each of the crops included in the Plan. The economic aspects of the enterprise will also have to be indicated clearly.

In summing up, it may be stated that it has been possible to buy some years to think about proper and scientific land use and cultivation plan in general for the country. It may be possible to produce the required quantity of foodgrains on much smaller areas than what is devoted at present. Coarser foodgrains may have to find a way or usage through animals and birds. There is urgent need to increase the availability of foods rich in right quality proteins. It may be in the form of vegetable or animal protein or judicious combination of both. Production of oil bearing crops and other crops required for industry for internal consumption as well as for export, has to be increased. Careful vigil has to be kept on the world market and plan for production of those products that are in demand already or are likely to be in demand in the world market in future. The consumption of fruits and vegetables is low and there is urgent need for increasing the same. There is prospering world market too not only for fresh fruits and vegetables but also for processed ones. It is not only the production aspect that has to be kept in view but also other aspects of employment potential and distribution of benefits of production. Cropping patterns and cultivation plans have to be conceived keeping all these objects in view. They will have to be tested in different regions. Time is ripe for diversification of agricultural production with an ultimate objective of getting maximum per unit area and also confer maximum benefits to every individual depending on land. This is a challenge and an opportunity to every agricultural scientist in general and agronomist in particular in the country.

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ADVANCES IN SPICES RESEARCH

M. C. NAMBIAR
Project Co-ordinator (Spices and Cashew)
Central Plantation Crops Research Institute,
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DURING the year 1970, the export of spices accounted for 39 crores of rupees. Of this, 40% was accounted for by black pepper, 29% by cardamom, 10% by turmeric, 7% by ginger, 3% by chillis and 12% by other spices and curry powder.

There are innumerable problems facing the spices industry and trade in India which have adversely affected the production in recent years. The major factors are poor genetic stock, failure in modernisation of cultivation practices as well as plant protection measures. The ICAR had financed a number of *ad hoc* research schemes for improvement of spices industry. Valuable results have been obtained from these research schemes operated at various centres under the aegis of different organisations. The All India Co-ordinated Project which has come into operation from 1st October, 1970 is aimed at tackling the problems facing the spices industry and increasing production of commodities.

Pepper

Pepper is the most important and earlier known spices of India which is considered to be the 'King of spices'. Indian pepper had had a prominent place in the world market till the beginning of the nineteenth century when Indonesia, Malaya, Sarawak and other far eastern countries started pepper cultivation on a commercial scale. India produces about twentysix thousand tonnes of pepper annually and bulk of the produce, i.e. nearly eighteen thousand tonnes, is exported.

Studies made on different aspects of pepper cultivation during the past two decades have yielded valuable information. A varietal collection comprising 69 varieties and types from India, Ceylon and Indonesia is being maintained and evaluated at the Pepper Research Station, Panniyur, Kerala. A new hybrid variety called Panniyur I (Photo above) has been evolved using

Cheriyakaniakadan and *Uthiramkotta* as male and female parents respectively. Panniyur I is a high yielder capable of giving 3-4 times the yield of the common local varieties. It is an early bearer which begins to yield from the second year of planting if properly looked after. The quality of Panniyur I is good and it compares very well with all other indigenous and exotic varieties. This has been found suitable for different agro-climatic conditions. The hybrid comes up well under east coast conditions as well and very good plantations of Panniyur I have been raised by Andhra Pradesh Forest Department.

Propagational trials have shown that planting rooted cuttings is the most efficient method for getting successful establishment. There is no valid data regarding manurial requirement of the crops. However, based on the available information, the manurial schedule recommended now is 100 g N, 160 g P_2O_5 and 60 g K_2O in addition to 9 kg of well-composed farmyard manure or compost per vine per year. Application of lime at the rate of $\frac{1}{2}$-1 kg per vine during alternate years is economic.

The 'pollu' flea beetle—*Longitarsus nigripennis* and 'wilt' diseases are the important menaces affecting pepper cultivation. The grubs of this small shining yellow flea beetle bore into, and feed within the berries making them hollow and dry. One grub destroys nearly 3-4 berries. D.D.T. 0.2% spray twice a year (July and October) is recommended for the control of this pest. In view of the high residual toxicity of DDT and such other chlorinated hydrocarbons, alternative insecticides which are efficacious in controlling this pest as also other pests affecting the crop are to be tried. Field trials using modern insecticides are being laid accordingly. The slow wilt caused by *Fusarium* sp., and *Diplodia* sp. and quick wilt by *Phytophthora palmivora* var. *pipins* are the two most important diseases of pepper, causing a great threat to pepper industry particularly in North Kerala. The slow wilt can be controlled by drenching the soil around the root zone of the affected vines with 0.1% ceresan wet. Preliminary studies on quick wilt disease have indicated that application of 1% Bordeaux mixture twice before the South-west and North-east monsoons respectively and drenching the soil with 0.1% wet ceresan wet after the receipt of South-west monsoon are effective.

Further collection and evaluation of germplasm are to be made to select high-yielding varieties resistant/tolerant to diseases and pests and exploitation of hybrid vigour by hybridisation and selection and evolution of new varieties. Pepper being a cross-pollinated crop, propagated vegetatively by cutting, it is possible to exploit the locked up variations and select superior types by screening large number of seedlings raised from each variety. While breeding new varieties, care should be taken for higher quality of the produce. Being an export-oriented crop, export market preference should be given priority in the breeding programme. Being a dry crop subject to heavy incidence of pests and diseases, evolution of an integrated method of control for combating them in combination with foliar application of nutrients has got wide scope.

Detailed investigations on the nutritional requirements are yet to be carried out. Experiments to determine the nutrient requirement of pepper, with live and dead standard, invite immediate attention. The quality of pepper in relation to fertilizer application and at different stages of growth and development of the berries is worth investigating.

Cardamom

Cardamom (*Elettaria cardamom*) known as the 'Queen of spices' occupies an important position as the second largest foreign exchange earning spice crop next only to black pepper. India is the important supplier of cardamom to the world market. The most popular varieties grown are Mysore, Malabar and Vazhukka. The larger cardamom of commerce, *Amomum sabulatum*, is cultivated in Assam and Bengal regions.

Realising the importance of the crop in the national economy, a survey and study of cardamom was initiated at Singampatti with the assistance of ICAR in 1940. Subsequently, in 1950s, ICAR sanctioned schemes for intensive study in Mudigere and Pampadumpara. Very valuable investigations have been initiated at these centres and valuable information gathered on flowering, fruit-set, cultural requirements, nursery technique, and pest and disease control. Survey, collection and evaluation of germplasm received top-most priority in these stations. 'Hema' series 1 to 12 evolved at Mudigere, seven selections at Pampadumpara, 5 selections at Appangala and Singampatti two selections, namely S. 71 and S. 81 were found to be high yielders. S. 71 was found suitable for low rainfall areas. The average yield on plantation scale works out to not more than 25 kg/ha, whereas these selections are able to give three-four-fold the yield under proper management. The quality of the fruit is also very high. Intra-and inter-varietal hybridisation attempted at Singampatti have also yielded a few hybrids which are under trial. The impact of research at these centres was not very much on production probably due to lack of co-ordinated effort to utilise the results of research.

Widespread occurrence of 'Katte' disease has considerably affected the productivity of cardamom. Earlier studies have shown that the disease is of virus origin and tramsmitted by banana aphid *Pentalonia* *nigronervosa.* Recent studies at Mudigere have shown that the spread of 'Katte' is internal rather than external. The spread of the disease within a plantation is more associated with vector activity rather than vectorial population. Investigations at Indian Institute of Horticultural Research, Hessarghatta, showed that a total of 13 aphid species including *Pentalonia nigronervosa* act as vectors of the virus. An isolate of 'Katte' agent has been found to be sap transmissible passing on to cowpea and crotalaria. If further investigations confirm these findings, it would prove very useful for evolving cross protection tests. Effective control of the disease can be obtained by spraying with a systemic insecticide like Dimethoate (Rogor) or Phosphamidon (Dimecron) at 0.05%; complete removal and destruction of diseased plants along with rhizomes; removal of partially decayed pseudostems after harvest, removal of alternate hosts like wild *Amomum* plants, avoiding gap filling by clonal material, and replanting with 'Katte'-free seedlings after a lapse of three months. Diseases like clump rot in the high ranges of Kerala, and nursery leaf spot caused by *Phyllosticta elettariae* in Mysore State for which effective control measures are yet to be evolved.

Among the pests affecting cardamom crop, the most important and destructive is cardamom thrips *Taeniothrips cardamom* which infest the inflorescence stalk, flowers and tender fruits. As a result of this damage, the inflorescence stalk gets stunted, flowers fall, and the capsules get malformed. Dusting with 10% BHC at monthly intervals was recommended. But in recent years the control of this pest has become highly complex because this treatment does not give satisfactory control of the pest. Field trials using different insecticides are now in progress.

Other pests of economic importance include the hairy caterpillars *Eupterote canariea, E. cardamomi, Lenodera vittate,* etc. stem and capsule borer, *Dichcrocis punctiferalis,* the rhizome weevil *Prodioctes heematicus,* etc. Integrated control schedules including biological control have to be worked out.

Ginger

Another important spice crop is ginger. India accounts for more than 50 per cent of world production. Other important ginger growing countries are Taiwan, Jamaica, Africa, Australia, Mauritius, etc. Among the exotic and indigenous varieties, Maran, Nadia, Thingpuri, Narasapattam and Wynad Manantoddy were found to be high yielders. The yield and recovery percentage of dry ginger in different varieties are given in the Table below.

Ginger

Variety	*Yield '000 kg/ha*	*Percentage of dry ginger to green ginger*
Rio-de-Janeiro	17—23	16.25
China	13—18	17.00
Maran	17—23	22.00
Nadia	17—23	20.00
Thingpuri	17—23	20.00
Narasapattam	16—20	21.09
Wynad Manantoddy	12—18	17.08

Ginger requires heavy manuring. Application of 25—30 tonnes of well decomposed cattle manure or compost per hectare at the time of planting and 300 kg ammonium sulphate, or other nitrogenous fertilizers on an equivalent basis, 375 kg superphosphate and 250 kg muriate of potash are applied as basal dressing at the time of planting and remaining ones in two split doses. Mulching of beds with green leaves is an important and essential operation. The beds are to be weeded and earthed up twice during the manurial application.

Among the pests affecting ginger, the most important is shoot borer—*Dichocrocis punctiferalis.* Spraying the crop with 0.03% endrin at monthly intervals, 2 to 3 times from the second month after planting, controls the pest. The most important disease of ginger is the soft-rot or rhizome rot caused by *Pythium* sp. and *Sclerotium* sp. Drenching the soil with cheshnut compound or Dithane Z-78 at 0.15% concentration is found to control the disease effectively.

Turmeric

Problems which require further studies

1. Evolving new high-yielding varieties having low fibre content, high recovery of dry ginger and high oleoresin content.
2. Standardisation of agro-techniques for different agro-climatic regions including the determination of optimum seed rate and spacing for high-yielding varieties.
3. Influence of intercropping on yield and quality of ginger and its economics.
4. Ginger is generally harvested at eight months' stage of growth. Yield and recovery of dry ginger are found to be better at this stage. Recent studies have indicated that the recovery of oleoresin is more in rhizomes harvested at 5 months stage of growth. Detailed investigations to determine the correct stage of harvest for different purposes in relation to yield and economic return to cultivators require immediate attention.
5. Utilisation of starch from spent ginger and isolation of protein for industrial use.

Turmeric

Turmeric is a tropical crop cultivated from almost sea level to 1200 m in places of moderate rainfall. India is one of the leading turmeric producing countries of the world. India produces annually 1.4 lakh tonnes and out of these, 0.11 lakh tonnes are exported every year.

The most important varieties are 'Duggirala', 'Tekurpeta', 'Kasturi', 'Pasupu', 'Armoor', and 'Chaya Pasupu'. Selection work carried out at the Turmeric Research Centre, Duggirala and Anantarajapet in Andhra Pradesh, resulted in isolation of four promising long-duration types, viz. Cll. 324, 325, 326 and 327 and one clone (Cli 317) in medium-duration types and one short-duration type (Ca. 73). The long- and medium-duration varieties come under *Curcuma longa* and short duration variety under *Curcuma aromatica*.

Like ginger, turmeric is also exacting in its manure requirements. Usually 40—50 tonnes of farmyard manure is applied at the time of land preparation. Chemical fertilizers like 60 to 100 kg each of N and P_2O_5, and 120 to 200 kg K_2O per hectare are applied in split doses as in the case of ginger. Two mulchings with green leaves may be done at 12.5 metric tonnes per hectare.

Among the diseases, leaf spot (*Colletotrichum capsici*), leaf blotch (*Taphrina maculans*) and rhizome rot (*Pythium* sp.) are the important ones. Spraying the crop with 1 per cent Bordeaux mixture is recommended to control the foliage diseases, and drenching the soil with 0.3 percent cheshnut compound to control rhizome rot.

Among the pests, the shoot borer *Dichocrocis punctiferalis*, the leaf roller *Udaspes folus*, the rhizome scale *Aspidiotus harti* are the important ones. Other pests like *Panchaetothrips indica*, hairy caterpillar *Diacrisia obliqua* and leaf beetles *Lema* Spp. have also been recorded. Spraying 0.05 per cent Dimecron was found effective in controlling shoot borer attack. The foliage pests can be controlled with 0.025 per cent Parathion spray.

Wide variations are available in the indigenous material for duration, yield, colour, curcuma content and curing percentage. Extensive collection of germplasm, screening and selection based on yield, quality and resistance to pests and diseases is the immediate necessity.

GROW MORE, MARKET MORE

FLORICULTURE IN INDIA IN THE LAST TWO DECADES

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In India, a wide range of ornamental plants can be grown due to the variation in climate in different regions of the country. It is also the place of origin of many plants of floricultural importance.

Since independence the importance of floriculture in town and country planning for beautifying the environment is being realised and floriculturists are working in close collaboration with architects and town planners in developing beautiful cities and towns.

In recent years, there has been a considerable demand for good flower seeds throughout the country and seed industry finds a tremendous scope for improvement and expansion.

In the western countries, specially in Europe, there is an enormous sale of fresh flower and efforts are being made to export cut roses to these countries. Improvement of important cut flowers will not only increase the potentiality of export but will also improve the trade in domestic market.

Orchids are considered to be the most beautiful flowering plants throughout the world and both cut flowers and plants are sold at a very high price. In spite of natural resources and favourable climate for successful cultivation of orchids, no attempt was made to produce hybrids and develop orchid industry in this country.

Important bulbous plants like gladiolus, amaryllis, lilium and tuberose can be grown extensively in various parts of India depending on the suitability of climate. Apart from the spectacular flower used for bedding and cut flowers, improvement of varieties and commercial production of bulbs have very good possibility of export.

Rose and jasmine are commonly used for extracting essential oil for perfume industry and development of improved varieties with high essential oil content will be of immense commercial importance.

Considering the importance of improvement in floriculture, the Indian Council of Agricultural Research has taken up an All India Co-ordinated Floriculture Improvement Project.

Introduction

Introduction of plants has been an important method of enriching the collection of ornamental plants in a country. In recent years, large number of species and varieties of ornamental plants have been introduced in India. Many varieties of Bougainvillea including 'Blonde', 'Lady Mary Baring', 'Rhodamine,' 'Glady's Hepburn', 'Golden Glow', 'Mahara' introduced by Lalbagh Gardens, Bangalore are now being widely grown. It also brought a number of varieties of *Hibiscus rosasinensis* from Hawaii which bear large flower of attractive colour and have proved very successful in mild tropical climate. Some of the outstanding varieties are 'Comet', 'Cromwel', 'Grace Goo', 'Hawaii', 'Honi Honi', 'Hula Blue', 'Ruffle', 'Suzan' and 'Vasco'. *Mussaenda philippica,* a tall shrub brought from Thailand by the Indian Botanic Garden is growing well in humid tropical regions of this country and producing cluster of large white bracts during the summer and rains. The Agri-Horticultural Society of India has also introduced several ornamental plants during 1965–70. The pink and red varieties of *Mussaenda philippica* bearing many bunches of large coloured bracts, obtained from Thailand have established well. Two varieties of Bougainvillea with multiple bracts in white and pink colour, also introduced from Thailand are important additions to the collection of Bougainvillea in this country. Light yellow flowered *Nerium indicum,* introduced by Plant Introduction Division, I.A.R.I., has acclimatised well in tropical India.

Cuttings of *Saraca indica* rooted under mist, flowered after three months of potting.

Since 1954, large number of varieties of Dahlia and Chrysanthemum have been introduced in India through various agencies and they are now being grown successfully. Among the varieties of Dahlia, 'Prime Minister', 'Victor', 'Thelma Davidson', 'Croydon Monarch', 'African Jester', 'Kenya', 'The Master', 'Ucchu', 'Welcome' are some popular varieties of large decorative type. Several American varieties of chrysanthemum, e.g. 'Snow Ball', 'Temptation,' 'Ajina Purple', 'Mountaineer', 'Dream Castle', 'Kikubiori' are easy to grow and flower freely in different parts of India.

Although the collection of orchid hybrids in India is very small, compared to the numerous hybrids grown in various parts of the world, several hybrids of Cattleya and Vanda with spectacular flower have been brought to this country. Some of the attractive Cattleya hybrids are Blc. 'Snow Flame', Blc. 'Golden Medo', Blc. 'Stalin', Lc. 'Cleopatra', Lc. 'Golden Queen', Bc. 'Maisa'. Some outstanding hybrids of Vanda which have proved very successful in warm humid conditions of India include 'Manira × Onomea', 'Rosa Davis × Sandriana', 'Kamahele × Rothschildiana', 'Kamahele × Onomea', 'Jack Waiker' and 'Rothschildiana × Ohu Ohu'.

New Varieties and Hybrids

Bougainvillea. Dr B.P. Pal developed five varieties of Bougainvillea —'Dr R.R. Pal', 'Sonnet,' 'Stanza', 'Summer Time' and 'Spring Festival', the first one is a free flowering popular variety with attractive bract colour. From 'Mary Palmer', a variety bearing only white bract was obtained at the Agri-Horticultural Society. The variety was named in honour of Dr B.P. Pal and it is considered to be the best white variety of Bougainvillea in this country. At Lalbagh Gardens, Bangalore, several varieties of Bougainvillea, e.g. 'Bhabha', 'Lalbagh', 'Trinidad', 'Thima', 'Yellow Queen' were evolved. Messrs K.S. Gopalswamienger and Sons in Bangalore and Soundaraya Nursery in Madras developed a number of attractive and popular varieties. 'Gopal', 'Jaylaksmi', 'Krumbiegal', 'Mahatma Gandhi' were selected by Messrs K.S. Gopalaswamienger and Sons and 'Versicolour', 'Sensation', and 'Flame' by Messrs Soundaraya Nursery. Systematic attempt is also being made to develop hybrids of Bougainvillea at the Indian Institute of Horticultural Research at Hessarghata.

Hibiscus. In Bangalore, many varieties of *Hibiscus rosa sinensis* set seeds freely and large number of hybrids of Hawaiian varieties have been developed at the Lalbagh Gardens, Indian Institute of Horticultural Research and also by nurserymen.

Annuals. An important achievement in floriculture in this country is the commercial production of F_1 seeds of Petunia by Messrs Indo-American Hybrid Seeds in Bangalore. It is being exported to the U.S.A. At I.A.R.I., F_1 hybrid of French Marigold obtained from crosses between 'Petite Orange' × 'Rusty Red' and 'Naughty Marrietta' × 'Pygmy' increased the weight and number of flowers respectively. In African marigold F_1 hybrids between 'Hawai' × 'Cupid Orange' and 'Alaska' × 'Spungold' were superior to the parents.

Hollyhock. Marked improvement in flowering in Hollyhock was recorded in F_1 hybrid developed at I.A.R.I. Large number of double flowers were found to produce in a very attractive manner on the main stem.

Mutation of ornamental plants. At the Division of Vegetable Crops and Floriculture, I.A.R.I., investigations are also being made to induce mutations in floricultural plants. Improvement in vegetative growth and flowering has been recorded in 'Bells of Ireland' by using gamma irradiation. Changes in the form and colour of flower has also been obtained in Tithonia. Treatment with E.M.S. (ethyl—methane suphonate) has produced mutant in Sweet Pea with more attractive flower.

At the Experimental Station of Fertilizer Corporation of India at Sindri, three distinct mutants have been reported in chrysanthemum var. 'Pride of Madford' by treating the plants with semi-acute irradiation. Two somatic mutants from a red flowered variety of Hibiscus have also been obtained.

Gladiolus. Selection of gladiolus varieties under Delhi condition was undertaken at I.A.R.I. Among the 122 varieties tested, several promising varieties like 'Ratna Butterfly', 'George Mazure', 'Jo Wagener', 'Geoff Whiteman', 'Snow Princess', 'Friendship', 'Apple Blossom' 'Rose Spire' and 'Gold Bust' which produced long spikes, large number of flowers of attractive size and colour were selected.

In a similar investigation of selection of promising varieties of gladiolus at the National Botanic Gardens, Lucknow, 'Agnita', 'American Express', 'Aristocrat', 'Elan', 'Goliath Queen', 'Juliana' and 'Summer Pearl' were selected.

Water Lily. From a collection of 50 varieties of American Water Lilies at N.B.G., several outstanding varieties, as for example 'Pamela', 'White Gigantea', 'Isabelle Pring', 'Blue Beauty', 'Chromatella', were selected.

Marigold. Twenty-five varieties of French marigold were grown and tested at the above garden for bedding as well as cut flower poduction. The varieties-'Claudia', 'Eldanado.' 'Gold Coast', 'Orange Flame', 'Harmony', 'Lemon Drop', and 'Sunny' were considered useful for the purposes.

Selection for Temperate Climate. Systematic investigations on the selection of varieties of some important perennial and annual ornamental plants suitable under temperate condition of this country were carried out at Katrain sub-station at I.A.R.I. in H.P.

Gladiolus. Fifty-two varieties of gladiolus were grown and tested during 1964–70. 'Snow Princess', 'Gold', 'White Gold', 'Traveller', 'Oklahoma', 'Consonent', 'Misty Eyes', 'Erato', 'Wickman' and 'Pink Jurl' were selected as the promising varieties.

Narcissus. Among the nineteen varieties tested at Katrain, 'All Yellow', 'Cheerfulness', 'Scilly White', 'Ornatus Maximus', 'Geranium', 'Florea' and 'Tazetta Daphne' were found to show satisfactory growth and flowering.

Daffodil. In daffodil also a number

of varieties were selected which include 'Brunswick', 'Home Spun', 'Scarlet', 'Elegance', 'Westler' and 'Texas'.

Aster. Twenty varieties of aster were grown and assessed during 1966–71 and five varieties namely 'Cascade', 'Pompon Chikuma', 'Pompon Aroke', 'Dwarf Queen' and 'Super Giant' were selected.

Sweet Pea. In a selection trial on 20 varieties of sweet pea, 'Ranona' 'Elenor', 'Variegated', 'Grace' and 'Miranda' were found to produce large number of flowers of good quality. The selected varieties were less susceptible to diseases.

Dahlia. Among the varieties of Dahlia of Decorative, Cactus and Pompon types grown at Katrain, the following varieties showing satisfactory growth and flowering were selected. Large decorative type-'Powder Puff', 'African Queen', 'Magnificient', 'Avalanche' and 'My Beauty.'

Cactus type—The 'Cardinal' 'Annapurna' 'Carnival' 'White Pearl', 'Pride of Holland' and 'Orgeo'.

Pompon type. 'Sunrise', 'Tam Tam', 'Albino', 'Dustone Stone' and 'Profiger'.

Research on Rose

Introduction of many rose varieties from various countries has enriched the collection of roses in India. 'American Heritage', 'Papa Meilland', 'Eiffel Tower' 'Super Star' 'Blue Moon', 'Queen Elizabeth', 'John F. Kennedy', are several outstanding and popular varieties introduced after 1960.

The existing collection at I.A.R.I. consists of 2000 varieties belonging to different classes of roses, viz. Hybrid Tea, Floribunda, Polyantha, Miniature, Climber and Shrub.

Breeding of Roses. Breeding of rose has been a very fascinating work for the amateur and professional rose growers in many parts of the world. In India, B.S. Bhattacharjee, a commercial rose grower at Deoghar first started breeding of roses for developing new varieties suited to tropical condition. He has so far evolved about 115 varieties and 'Heart Throb', 'Haridra' 'Joy', 'Sri Arabindo', 'Sugandha', 'Vichitra' and 'Zakir Husain' are some of his popular varieties.

At the Indian Agricultural Research Institute, rose breeding was taken up systematically by Dr B.P. Pal in the year 1961. Some of the important varieties evolved by him are, 'Delhi Princess', 'Dr Homi Bhabha', 'White Nun', 'Banjaran', 'Nutkhut', 'Poornima', 'Kum Kum', 'Belle of Punjab', 'Paharan'. The profusion of flowering on 'Delhi Princess' is much better than any of the exotic varieties under Delhi conditions.

Simultaneously, the breeding work was started in the Division of Horticulture in the year 1962 and in all 20 varieties have so far been evolved. The important ones are—'Pusa Sonia', 'Ganga', 'Bhim', 'Surekha', 'Hans', 'Sujata' and 'Gulzar' amongst Hybrid Teas and 'Himangini', 'Prema', 'Shola', 'Suryodaya', and 'Rupali' in Floribunda and 'Swati' in Polyantha. Besides these, an outstanding rose variety 'Mohini' evolved in this Division, has an unusual chocolate brown colour and has evoked international interest. Besides evolving decorative, exhibition and garden roses, the rose breeding work is aimed at evolving varieties with high essential oil content, suitable for export of cut blooms and resistant to diseases and pests.

Mutants for flower colour have been obtained at I.A.R.I. in varieties of roses, viz. 'Christian Dior', 'Queen Elizabeth' and 'Kiss of Fire' by treating the buds with gamma irradiation.

Trial on Rootstock. Rootstock of *Rosa indica* var. 'Odorata' was found better than the commonly used rootstock Edward (*Rosa bourboniana*) in vigour and production of more number of flowers per bush under climatic and soil conditions of Delhi.

Spacing. A closer spacing of planting, (60 × 30 cm) was found better than the usual spacing of 60×60 cm in variety 'Super Star' for commercial plantations. Closer spacing increased the production of export quality flowers to double per unit area as compared to the usual spacing.

Export of Roses. The feasibility of exporting rose flowers to Europe was established by the success of five experimental consignments sent to Frankfurt, Rotterdam and Paris during March 1969 from the Division of Horticulture, I.A.R.I., New Delhi in collaboration with the State Trading Corporation of India. The suitable varieties were selected and the techniques of pre-treatment and packaging of blooms were standardised prior to sending those consignments abroad through considerable research work. Three rose varieties —'Super Star', 'Queen Elizabeth' and 'Happiness' were found suitable for export.

The flowers in tight bud is the right stage for cutting for export. The flowers with stalks immersed in water were kept in the cold room at 40–45°F for about 6 to 12 hours depending upon the outdoor temperature. During winter (Dec.-Jan.) treatment of 6 to 8 hours was sufficient, while a longer duration of 8 to 12 hours was necessary in March–April.

The flowers were packed in 4—ply corrugated cardboard boxes of 100 cm (length) 32.5 cm (width) 16.5 cm (height) size accomodating 80 to 120 roses having 60 to 70 cm long stalks.

Nutritional Requirements of Roses. With a view to finding out optimum doses of NPK for roses, a trial was laid out at the National Botanic Garden, using the variety 'Belcanto'. It was observed that NPK in ratio of 12:12:6 produced large number of

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flower buds and increased the size of buds. In a subsequent experiment, foliar sprays with 0.4 gm magnesium sulphate, 0.3 gm manganese sulphate, 0.1 gm boric acid and 0.2 gm ferrous sulphate (in the form chelate iron) in combination NPK in 12:12:6 ratio was found to show the best result.

Researches on Jasmine

Extensive investigations on the improvement of jasmine are being carried out at the Tamil Nadu Agricultural University, since the work started at the Agricultural College and Research Institute at Coimbatore.

Selection of Species and Varieties. Among the 50 species and varieties of jasmines collected and maintained at the Agricultural University, several promising types have been selected. *Jasminum calophyllum* was found to produce a large number of flowers per plant. An improved, high-yielding mite-resistant variety of *J. auriculatum* was selected which produced about 4000 kg of flower per acre compared to about 2500 kg in the local variety of this species. In *J. grandiflorum,* a high-yielding triploid type was also isolated.

In order to develop more improved types with high yield and other desirable characters, hybridisation, mutation breeding and induction of polyploidy have been taken up on important species and varieties of jasmine.

Cultural Practices

Manuring. In *J. auriculatum* maximum yield of flowers was recorded by the application of 120 gm of ammonium sulphate and 240 gm each of superphosphate and muriate of potash twice a year in June and December.

Pruning. In *J. sambac*, pruning after the normal flowering season stimulated another flush of flowers. It was also recorded that late pruning reduced flowering in *J. auriculatum.* Use of chemical defoliant on *J. auriculatum* (Pentachlorphenol) proved to be an effective substitute for pruning and also increased the yield of flowers by about 65 per cent.

Extraction of Essential Oil. Extraction of essential oil from flower of *J. auriculatum* in laboratory scale showed a recovery of 0.35–0.40 per cent which compared favourably with 0.28–0.34 per cent recovery recorded in other countries.

Improvement

Mist Propagation of Ornamental Plants. Large number of woody and semi-woody ornamental plants are propagated by layering which is a more laborious and expensive method than propagation by cuttings. Trees are mostly raised from seeds. An extensive investigation was taken up at the Birla Laboratory of the Agri-Horticultural Society to stimulate roots in cuttings of woody ornamentals by planting them in mist chamber and using root-promoting chemicals. It was possible to induce high percentage of rooting in about 300 species and varieties of plants including several species of trees which, under ordinary conditions, failed to produce root or showed very low percentage of rooting. Treatment with IBA (indole butyric acid) in talc at 3000 or 6000 ppm depending on the nature of wood, markedly promoted rooting. The rooted cuttings also showed very high percentage of survival and the survived plants grew well. Mist propagation can be successfully adopted on a commercial scale for multiplication of tropical ornamental plants.

Propagation of Orchids. In the Tissu Culture Laboratory at the National Botanic Gardens, multiplication of orchids from seed and meristem has been standardised.

Propagation of Lilium. In an experiment on propagation of Easter lily (*Lilium longiflorum*) by soft wood cuttings, IAA at 20 ppm was found very effective in stimulating root formation.

Improvement in Growth and Flowering of Pot Plants. In view of the efficacy of the growth retardants in developing dwarf attractive pot plants, investigation was carried out at the Agri-Horticultural Society on 45 species and varieties of tropical shrubs and 40 types of annuals and bulbous plants. Among the different growth retardants, CCC (2 chloroethyl trimethyl ammonium-chloride) was found very effective in suppressing the height of the treated plants of different varieties of *Hibiscus rosasinensis, H. Syriacus* and *H. mutabitis.* The treated plants also developed larger number of branches and flowers. Both CCC and B-Nine (N-dimethyl amino succinamic acid) proved effective in reducing the height of different varieties of Bougainvillea but the latter chemical increased the number and size of bracts. CCC also markedly retarded the plant height and improved flowering in *Galphimia gracilis, Clerodendron macrosiphon, Malva sylvestris* and *Althea rosea.* B-Nine showed high degree of retardation and appreciable improvement in flowering in *Ixora singaporensis, Lantana camara, Brunfelsia americana* and *Dahlia variabllis* and *Senecio crunetus.*

Improvement in Seed Production. In places where winter is short and temperature rises fairly high at the flowering time, many winter annuals fail to produce seeds or produce small amount of seed of poor quality. In order to improve seed formation in carnation and pansy experiments were taken up at the Birla Laboratory of the Agri-Horticultural Society, Calcutta. Marked increase in the number and weight of seeds was recorded in carnation and pansy by exposing the plants in flowerbud to a temperature between 16-18°C in glass house. Application of GA (gibberellic acid) at 10 and 100 ppm and NAAm (naphthylacetamide) at 1 ppm caused significant increase in yield of seeds in carnation under outdoor condition. Treatment with GA in 1 ppm also improved seed formation in pansy under outdoor condition.

Nutrition of Ornamental Plants. In order to improve the growth and flowering of popular ornamental plants, an investigation was taken up at the Agri-Horticultural Society to study the effect of nitrogen, phosphorus and potassium. Deficiency of nitrogen and phosphorus caused marked reduction of growth and flowering in Bougainvillea, Hibiscus, tuberose, Dahlia, Hemerocallis, Gerkera, Cosmos, Coreopsis, Salvia, Aster and Dianthus and developed symptoms of starvation on the leaves. Nitrogen deficiency failed to produce flower in Dahlia and tuberose, while high level of nitrogen significantly promoted growth and flowering in Bougainvillea, Hibiscus Dahlia, Gerbera, Salvia and rose. Effect of potash deficiency, however, was less pronounced compared to nitrogen and phosphorus.

Gladiolus. Response of P and K fertilization to growth and flowering of gladiolus var. 'Debonair' was studied at the National Botanic Gardens. A basic application of F.Y.M. at the rate of 0.124 cu. meter and 200 gm each of single superphosphate and potassium sulphate per sq metre markedly improved growth and flowering.

In the Coordinated Project in Floriculture, extensive work on the improvement of rose, jasmine, bougainvillea, gladiolus, amaryllis, gerbera, pansy and petunia has been taken up at the Division of Vegetable Crops and Floriculture, I.A.R.I. Investigations on improvement of orchids, bulbous and annual ornamental plants will also start at the other two centres of the project in Calcutta and Shillong in September, this year.

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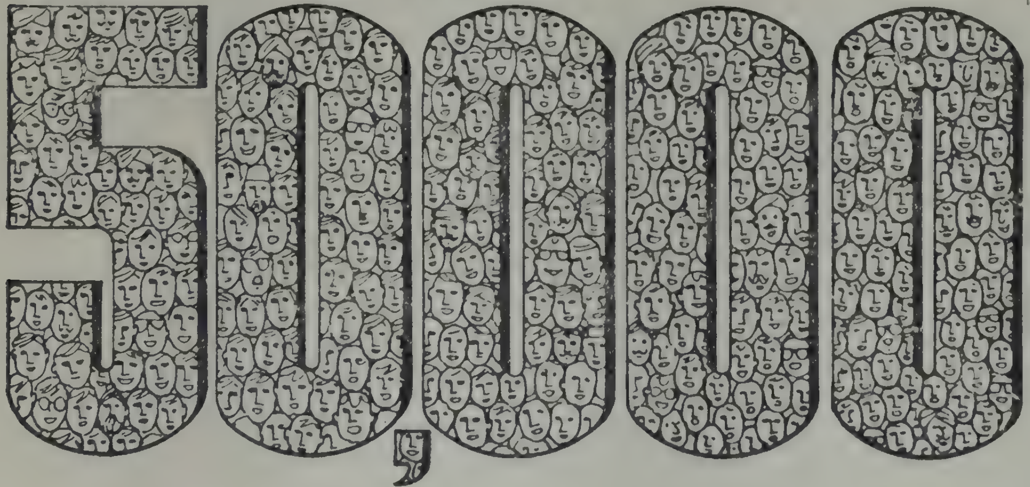

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SOYBEAN CAN RAISE NUTRITIONAL STATUS OF HUMAN DIET

MAHABAL RAM, C. KEMPANNA and A. BALASUBRAMANIAN
Indian Council of Agricultural Research, New Delhi.

An expert survey conducted by the United Nations Food and Agricultural Organisation revealed that malnutrition (imbalanced food) was much more dangerous to human health than underfeeding. This situation is becoming more and more apparent in South-east Asia including India. It is in fact a general phenomenon uniformly occurring with all age groups irrespective of the sex and the class of society. However, it is more common and well pronounced in growing children and the nursing mothers of the vulnerable (economically) sections of the society. Apparently, economic backwardness together with the lack of sufficient knowledge about the *dietary regimen* seems to constitute the major cause. But the factor that has a potential bearing on this problem and this cannot be so easily ignored is the lack of adequate supply of proteins or the protein augmenting sources not-withstanding the economic backwardness or otherwise. For example, the minimum requirement per capita of vegetable protein is 54 grams; but only 45 grams could be availed of so far. Similarly, only 5.2 grams of animal protein are available against the per capita targetted requirement of 10 grams.

It is indeed gratifying that several measures have been undertaken at the national level to augment the supply of protein-rich products like milk, egg, meat, fish, vegetables, pulses, etc. With all this it is feared that, according to the assessment made by the National Food Congress (1970), the prospects of raising the nutritional status of the human diet to the targetted or required level even by 1981 are not bright enough. It is, therefore, imperative to explore the alternative sources to fill the vaccum or, and in this context, amongst other things, soybean figures out prominently.

Soybean with as high a protein content as 42 per cent occupies an exalted position amongst the protein-rich legumes. Besides, it has other nutritional constituents as shown in the following Table.

TABLE 1. AVERAGE NUTRITIONAL COMPOSITION OF SOYBEAN

Chemical element		*Percentage of available quantities*
Total protein	..	42
Crude fat (as ether extract)	..	21
Ash	..	6
Crude fibre	..	2.8
Moisture	..	7
Available lysine (as % of protein)	..	6.1

(After Y.B. Rangnekar, Proceedings of the third All India Soybean Conference, Jabalpur, September, 1970).

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From the cost considerations, soy-protein is the cheapest as could be seen from the data in the following Table.

TABLE 2. PRODUCTION OF SOY-PROTEIN IN COMPARISON WITH THAT OF MAJOR PULSES, CEREALS, MILK, MEAT, ETC.

Foodstuff	*Average yield of grain per acre*	*Yield of protein in kg/acre*
Soybean	—	254.0
Other legumes	—	146.5
Maize	—	161.5
Wheat	—	90.0
*Milk	1390 kg	48.5
**Meat	171 kg	29.0

(Roy E. Martin, third All India Soybean Workshop, 1970).

*Milk produced by cows fed on grass grown on one acre land.

**Meat produced by animals fed on grass grown on one acre land.

Soy-protein is rich in quality. It has as many as eight amino-acids which are very essential in human nutrition and have as high a lysine content as 6.1 per cent of the total protein. It contains sufficient amounts of vitamin B-complex, thiamine and riboflavin, although it is poor in nicotinic acid.

In so far as its nutritive value is concerned, it compares favourably well with the other common pulses like *arhar* (*Cajanus cajan*) and gram (*Cicer arietinum.*)

TABLE 3. NUTRITIVE VALUE OF SOYBEAN AND THE OTHER PULSES

Food stuff	*Protein %*	*Biologcal value*	*Net protein utilisation*
Soybean	42	57.3	21.5
Gram	20	63.7	11.9
Arhar	23.6	61.7	13.2

The importance of soy-protein over animal proteins can be summed up as follows:

1. Soy-protein is of high quality and is comparable to milk-protein which is ideal and well balanced.
2. Can be stored for long time in the seed without deterioration or decomposition under the room temperature (without refrigeration).
3. It can be consumed by dissociating it from the fat.
4. More protein can be obtained from the per unit area (refer Table 2).
5. Lower in cost than that of animal protein.

Nutritive value of soy-flour was evaluated by Dr. Rangnekar of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur through rat-feeding tests. The groupwise diets contained:

(a) Wheat-flour chapati—alone.

(b) Chapati of 75 per cent wheat flour + 25 per cent soya flour. Processed according to cottage methods.

(c) Same as (b) but soy-flour was autoclaved at 110 degree centigrade for 15 minutes.

(d) Same as (b), but the soy-flour was from the roasted bean.

The results of these tests are summarised in Table 4.

TABLE 4. AVERAGE WEEKLY GROWTH RATE OF RATS ON BASAL POOR DIET CHAPATI CONTAINING SOY-FLOUR

Soyflour	*Estimated % protein in diet*	*Average weekly gain in grammes (10 week period)*	*Percentage increase over control*
1. Full wheat flour chapati	14.2	5.3	—
2. 75 per cent wheat flour + 25 per cent soy-flour processed by cottage methods	21.0	7.0	32.0
3. 75% wheat flour + 25% autoclaved soybean flour	21.6	6.4	22.6
4. 75% wheat flour + 25% soy-flour from roasted beans	21.0	6.3	19.0

Apparently, the incorporation of 25 per cent soy-flour in the diet increased the body-weight of rats by 32 per cent over those fed by only wheat flour chapati, obviously due to increase in the protein content of the diet with which the rats were fed during the trial.

Profiles of soy-protein products are as follows:

1. Dal like products
2. Beverages
3. Flour products like bread and chapati
4. Milk extensions
5. Snacks like samosa, kachodi and papads
6. Cheese and curds
7. Textured products
8. Child feed at school lunch programmes

9. Meat extensions
10. Use in breakfast

How soybean can be utilized by housewife

Soybean can be utilized by housewife in four kinds of preparations as shown in Table 5.

TABLE 5

Seed preparations	*Breakfast*	*Lunch dish*	*Milk products*
(a) Water soaked deep fat fried	(a) Dahi Bada	(a) Vegetables	(a) Curd
(b) Green pod roasted	(b) Pakoda Namkin	(b) Chapati	(b) Tea
(c) Water soaked Soy-baked	(c) Gulab-Jamun	(c) —	(c) Milk
(d) Sprouted-soybean raw	(d) Pakoda Sweet		

Methods of preparation of different soybean recipes

1. *Water-soaked soybean deep fat fried*
   Soak the soybean overnight in water. Rub it to remove seed coat and fry it in deep. Mix the condiments and salt to taste.
2. *Green pod roasted*
   Mature soybean pods can be roasted on fire and may be served as such for eating.
3. *Water-soaked soybean-baked*
   Soak the soybean seed in water overnight. Bake it on hot iron pan, salt to taste.
4. *Sprouted soybean raw*
   Soak the soybean seed in water. Allow it to sprout. Mix in salt, lime and condiments.
5. *Dahi Bada*
   Soak in soy pulse (hulled) overnight. Mix with green gram pulse (or water soaked) by 15 per cent. Grind it properly. Prepare Dahi Bada according to standard method followed by housewives, hotels, etc.
6. *Pakoda namkin*
   Mix 15 per cent soy-dal in gram dal-flavour. Mix salt and condiments, etc. Prepare pakoda (namkin) by standard methods as followed by housewives and hotels, etc.
7. *Pakoda sweet*
   Mix 15 per cent soybean flour in gram dal-flour. Mix sugar as much as needed. Prepare sweet pakoda according to standard methods.
8. *Gulab jamun*
   In place of wheat flour (maida) soybean flour is used. Gulab jamun is prepared according to the normal procedure.
9. *Puri and Chapati*
   Mix 15 per cent soybean flour with wheat flour. Prepare puri and chapati as usual.
10. *Vegetables*
    Soybean seeds from green pods are mixed with potato in 1:1 ratio. Vegetable is prepared as usual putting desired quantity of oil, salt and condiments.
11. *Curd*
    Soybean milk is prepared from overnight water soaked seeds. This milk is mixed with buffalo milk in 3:1 ratio. Starter is added to make curd.
12. *Tea*
    Tea is prepared as usual. Soy milk is added in place of common buffalo milk.
13. *Milk*: *How to prepare soy milk?*
    Soy milk is very nutritious, cheap and easy to prepare, but due to beany or bitter throat catching flavour, most Indian people do not like it. Researches conducted in United States indicated that enzyme lipoxidose, which is naturally present in soybean is the cause of the unpleasant flavour. This problem may be solved by grinding the beans with boiling water. The brief summary is given below. This makes the protein soluble and inactivates anti-tripsin present in soybean, which hinders protein digestion.
    (i) Soak the beans in cold water for 5—6 hours, if not overnight.
    (ii) Take out the bean from water.
    (iii) Pre-heat the grinder.
    (iv) Grind soaked bean with boiling water. (9 parts water +2 parts soaked beans) at minimum temperature of 80 degree centigrade.
    (v) Filter out the milk. Filtered cake is used for animal or human food.
    (vi) Boil the soy milk for 30—60 minutes to destroy antitripsin.
    (vii) Formulate with sugar, flavour,etc.
    (viii) Cool it and use it. It can be kept 8 hours without refrigeration. Shelf life 1—5 days with refrigeration.
    (ix) Sterilized milk for 12 minutes at 250 degree F and can be kept for six months.

Besides, soybean oil can be used for domestic purposes in many preparations in place of mustard oil, coconut oil, groundnut oil, etc. The cake can be used for human food, animal feeds, etc.

Towards the Formulation of the Fifth Plan

POSITION PAPERS ON AGRICULTURAL RESEARCH EDUCATION AND MANPOWER

CROP SCIENCES

Wheat Research

The All-India Co-ordinated Project on the Improvement of Wheat involves an allocation of Rs. 70·0 lakhs for the Fourth Plan period. It is operating at 20 centres, some of which concentrate researches in particular subjects like rust diseases. While some of the high-yielding dwarf varieties have helped the country to double its wheat production since 1965; the wheat improvement programme under the All-India Wheat Improvement Project continues to breed new varieties to replace the older varieties like Kalyansona and Sonalika, in case the latter show signs of going down to new races of rust disease. Among the new releases are Moti, Shera and Pusa Lerma. These and some other promising varieties are undergoing adaptive trials in different wheat zones. Moti produced the highest yields at several places, has excellent grain type and is recommended for western Uttar Pradesh. Shera has a good resistance to black and brown rust; produces grain of excellent quality and is suited for late sowing in central India. Pusa Lerma, a mutant derived from Lerma Rojo, has amber coloured grains with better gluten content; it is resistant to black rust and has been recommended for Mysore State. Work done in the agricultural universities and the State Department of Agriculture has also resulted in improved wheats, like WG 357 in Punjab, Narbada 4 in Madhya Pradesh and NI 747-19 and NI 5439 in Maharashtra and UP 302 and UP 303 in U.P. The Madhya Pradesh and Maharashtra varieties are particularly suitable for rainfed conditions.

2. During the Fifth Plan period, it is proposed to intensify work on the breeding of wheat for rainfed conditions which prevail in major areas in central and western regions of the country as well as in north Bihar. Quality tests will be increased in number and scope in order to identify varieties suitable for making bread, biscuits, cakes and macaroni. Much of the baking industry has been depending upon imported wheats, which must be replaced by home grown wheats. Detailed tests have shown that Sharbati Sonora, Hira, UP 303 and UP 303 are suitable for bread making. An extension of their cultivation to meet the needs of the bakeries is intensified, specially on rust for which it is proposed to develop a major centre at Indian Agricultural Research Institute, New Delhi, besides organising a wheat rust survey.

Rice Research

The All-India Rice Improvement Project (AICRIP), charged with the responsibility of initiating a common national programme and integrating the research efforts which were more or less isolated from one another in the past, made an effective thrust in the programme of breeding high-yielding varieties of rice. Although the project came into existence in 1965, field facilities could not be developed for another year and the formal assistance to the research centres came into effect only in 1969 with the approval of the Fourth Five-Year Plan.

2. The headquarters of AICRIP at Hyderabad co-ordinates the programme of rice improvement at 7 zonal, 12 regional and 5 testing centres, besides having a strong research programme at the headquarters centre itself. The rice-growing area of the country has been organised into 7 zones, taking into account the agro-climatic differences. The major research centre in each zone is identified as the zonal centre. The main research centres in the States are recognised as regional centres. Twelve major rice-growing States are identified by one regional centre each. Three testing centres have been provided at Upper Shillong (Meghalaya), Kalimpong (West Bengal) and Imphal (Manipur).

3. The multi-disciplined approach of the AICRIP greatly helped in building up a large amount of useful breeding material which created considerable interest among rice workers all over India with the result that in addition to the 24 centres which are involved in the AICRIP programme deriving financial support from ICAR, the total number of centres participating in the testing programme by using varieties being developed in AICRIP is over one hundred. The total amount of allocation for AICRIP programme is Rs 160 lakhs.

4. The programme has so far resulted in the release of 14 varieties of dwarf habit and high-yielding ability.

Fourteen more varieties have been identified as high-yielding and have been recommended for pre-release multiplication or adaptive tests in order that the best of these could be selected for final release. These represent a duration of about 90 to 170 days. Some of these represent excellent grain quality and may rapidly replace the older high-yielding varieties like Jaya, IR-8.

5. Since crop improvement involves a multi-disciplined approach the staff that has been provided at the different zonal and regional centres represent the disciplines of breeding, agronomy, pathology and entomology. Some centres are being utilized for special programmes relating to particular problems such as Warrangal in Andhra Pradesh for breeding of rice varieties resistant to gall-midge and Khopoli in Maharashtra for testing varieties against bacterial leaf blight.

6. Some of the new rice varieties represent a better combination of quality and high yield, and disease and pest resistance than what the exotic varieties have. Particular mention may be made of IET 1039 and IET 1991 as representing varieties possessing yields of the level of Jaya, yet having a long slender grain; a combination of yield and quality which the rice research programme had failed to achieve so far. Vijaya is attracting attention because of its ability to maintain high yield level and performance efficiency both under cloudy and normal sunlight conditions in the rainy season and although slightly lower in yield as compared to Jaya, it has finer grain and resistance to leaf hopper and tungro virus. Cauvery and Bala are particularly liked for their early maturity; Ratna and Krishna for medium early maturity and good grain type. The suitability and acceptability or otherwise of the different varieties are now being tested through a programme of adaptive trials. In the past these varieties had not been sufficiently tested on account of a weakness in the extension efforts. Also research has not yet been able to breed varieties suitable for very large areas experiencing heavy rainfall and conditions of water stagnation during the rainy season to which the existing high-yielding dwarf varieties are not adapted. Also the degree of resistance to pests and diseases which the rice varieties must possess when grown under favourable conditions of growth as represented by high levels of fertilizer use was found wanting in these varieties. Therefore, the research programme is now emphasising analysis of factors which determine high yields, viz. nitrogen management, and pest and disease control through breeding of varieties which possess fair degree of tolerance or resistance to them. In absence of the desired degree of resistance to pests and diseases and being vulnerable to high rainfall and waterlogged conditions, the high-yielding varieties of rice could not enjoy the stability in yield which the farmers demand before they would be prepared to invest in a substantial measure in high level production. Due to these constraints on high yield and the high cost involved in resorting to the plant protection measures recommended for these varieties, the areas under high-yielding varieties of rice and increased production have been very moderate compared to the progress enjoyed by wheat.

7. Among other difficulties experienced during the Fourth Plan period have been (i) slow rate of seed multiplication of new varieties and (ii) weak technical support to the main centre of AICRIP.

8. A strong seed cell will be established in the Ministry for planning and implementation of programmes of rapid multiplication and distribution of quality seeds. The headquarters of the rice project will be strengthened by adding highly qualified experts in different disciplines which are at present manned predominantly by foreign experts. By crossing some of the best dwarf varieties with floating rices, an attempt will be made to have dwarf floating varieties which may enable such varieties to withstand deep water conditions also. The varieties presently available are suitable mainly for conditions of water drainage and water control which do not obtain in many of the important rice-growing areas.

9. One of the directions in which experiments will receive emphasis in the coming years will be in identification, breeding and testing of varieties suitable for direct seeding, under rainfed as well as irrigated, upland as well as wetland conditions. This is becoming necessary in view of the labour shortage and cost of labour involved in transplanting rice.

10. Considerable progress yet needs to be made in the breeding of varieties resistant to pests and diseases. Lately good sources of resistance have been identified and a number of crosses involving them have given strains which have varying degrees of resistance. These have to be carefully screened under conditions which require the use of green houses or insect chambers which will be added at suitable centres. Some strains already identified as highly resistant to gall midge are now ready for large scale tests. Resistance to tungro virus and leaf hopper in a fair measure is available in Vijaya and IR-20, but needs to be increased still further with the help of breeding material developed in India and elsewhere. Similarly with breeding for resistance to the dreaded bacterial leaf blight. All this work will be taken up in the coming years with the help of facilities that are proposed to be added at suitable centres.

11. A pilot project on the biological control of paddy pests will be taken up in addition to intensification of the present very modest programme of rice disease and pest survey and surveillance.

Maize Research

The-All India Co-ordinated Maize Breeding Project has been operating at seventeen centres representing different maize growing regions of the country. The total allocation for the Fourth Plan period is Rs 75 lakhs.

The co-ordinated research effort in maize has resulted in a number of high-yielding hybrids and composite varieties. Among the hybrids may be mentioned Ganga 4 and Ganga 5. Among the composite varieties, Jawahar has given evidence of a wide adaptability because of which its yield has been more stable than the other composite varieties, viz. Kisan, Ambar and Vijay.

In respect of nutritive quality, a considerable amount of work done to incorporate the high lysine associated with opaque-2 has made it possible to breed some composites which have given very satisfactory yields. Three of these, viz. Shakti, Rattan and Protina have been released. Their grain does not have the attractive flinty appearance of the ordinary maize and hybrids nor does the grain have as good a keeping quality as the normal varieties have under storage. Even so it will be necessary to develop a programme of popularisation of these varieties, emphasising their use, viz. for processing as food products rather than for being stored and consumed in the traditional manner. Such varieties are already in use for manufacture of food products in some countries. Trials have shown that Shakti is suited to Madhya Pradesh, Rajasthan and the Terai regions of U.P. while Rattan can be grown in Punjab and Rajasthan. Protina can be grown in more diversified agro-climatic regions involving Punjab, Rajasthan, Mysore and the Terai regions of U.P.

There has been considerable resistance on the part of farmers to accept maize hybrids and composites in spite of their better yielding ability. There has been demand for early maturing hybrids which are not yet available. Efforts made in the beginning of the Coordinated Maize Improvement Project to combine early maturity with high yield failed and these efforts were given up. In view of the present demand for early maturity, it appears that even moderate increase in yield of hybrids or composites may be preferred by farmers to higher yields with late maturity. Greater effort than what was made in the past to test the combining ability of lines resulting from the large number of varieties of early maize which have since been collected may give much better yielding hybrids or composites possessing the desired earliness.

One of the reasons for this slow acceptance of hybrid maize by farmers has been the cost involved in growing good crops of these. While composites which will enable the farmers to produce their own seed year after year will greatly reduce the cost involved in buying hybrid seed afresh every year, it is necessary also to cut down cost on account of plant protection measures. Therefore, effort will be made to breed composite varieties possessing the desired earliness as well as resistance to downy mildew, stalk rot and leaf blight which threaten them every now and then. With production costs becoming reasonable, and short early maturing maize composites or varieties finding a place in more intensive cropping pattern than what is followed now, it may become possible to produce enough maize for use of some of these as livestock feed. Therefore, attention will be paid also to breed varieties which would be particularly suitable for this purpose.

Ragi Research

The work on ragi and other millets has not received the same attention as bajra due to inadequate staff. It is proposed to intensify efforts on these crops also since their potential under severe drought is higher than other cereals. They are also found to be far superior in the nutritional quality particularly some minerals and essential amino acids.

Based on the trials conducted during the past 3 years, two varieties of ragi IE 901 and E3 4840 have been released for cultivation all over India with an average yield potential of 30 q/ha. Another variety IE-28, maturing in less than 100 days, has been released during 1972 in areas endemic to ragi mosaic. However, intensification of the efforts on resistance to blast and mosaic and a change of plant type in ragi need immediate attention. The processing of ragi and other millets will also be undertaken simultaneously.

Jowar Research

The All-India Co-ordinated Project for improvement of sorghum has been operating at ten main centres and three sub-centres. The funds allocated for the Fourth Plan period amount to Rs 60 lakhs. The programme of work had depended upon the use of exotic male sterile varieties for production of hybrid jowar, as well as breeding of high-yielding varieties from crosses.

Although satisfactory in respect of high-yielding ability, the jowar hybrids do not meet the consumer demands. Also, for some heavier rainfall areas there is need for high-yielding varieties or hybrids which have a longer duration than those already released and which possess fair degrees of tolerance to shootfly which is a serious menace to the present day hybrids.

Hybrid jowar CSH-1 both because of its high-yielding ability as well as early maturity, has been finding acceptance of farmers in areas where rainfall is somewhat low. But when the crop is caught by rain when the grain is mature, the quality of grain suffers considerable deterioration when the local variety may hardly show any ill-effect of rain at maturity. Therefore, CSH-1, which appeared to greatly interest the farmers on account of its early maturity and high yield, has lost favour except in the semi-arid areas of Mysore and some parts of Maharashtra. But where the rainfall is a little higher, the new released hybrid PSH-2 resulting from a cross between 1036 A × Swarna developed in Maharashtra under the Co-ordinated Sorghum Improvement Project has been found to be a much better variety. It has yielded even higher than CSH-1. Two more selections from crosses involving Indian types and the exotics have been reported to yield higher than Swarna which was released a couple of years ago.

Ever since the first successful hybrid sorghum was produced, it was realised that grain quality of hybrids of future must be an improvement over CSH-1. But the male sterile parent which had to be used for production of hybrid sorghum carried with it the factor for poor grain quality also. Therefore, research was directed at developing an alternative source of male sterility which has now been achieved. The Regional Research Station, Hyderabad, has now identified a high-yielding sorghum strain of excellent grain quality suitable for growing in the rabi (winter) season.

Bajra Research

The co-ordinated project, with an annual outlay of Rs 12 lakhs, started functioning with a nucleus co-ordinating unit in 1968 and eight centres could be staffed only during the past 1-1/2 years. The programme has resulted in the release of four hybrids HB-1 to HB-4 with a common exotic male sterile and two more hybrids have been recommended for release during the year 1972. HB-3 was recommended for arid and semi-arid conditions and HB-4 for adequate rainfall areas replacing HB-1 and HB-2. With the intensity of cultivation and higher yield potential of these hybrids, new problems of pests and diseases have assumed serious proportions. Among them, downy mildew and ergot, shootfly, midge and white grub have of late been limiting the anticipated level of production. The locals are also equally susceptible but the yield reduction in them was lower due to their poor level of productivity. The above hybrids have been able to give an average yield of 25 q/ha under moisture stress and 50-60 q/ha, under better management and adequate moisture. The high susceptibility of the only source of male sterility to downy mildew and ergot has aggravated the problem in the absence of adequate standards of seeds supplied at different levels of multiplication. The yield of the hybrids is nearly four-fold over the locals despite these limitations.

Due to the epidemic conditions of ergot and downy mildew, an intensification of the effort on identifying donors for resistance has resulted in the isolation of nearly a score of West African stocks possessing resistance. However, these were poor in plant type and late in maturity and unsuitable for direct cultivation. They are used as donors in crosses with the existing inbreds and for alternate sources of male sterility.

Five more new male-steriles, three developed at Ludhiana and one each at Kanpur and Jamnagar primarily to diversify the breeding material, have been evolved. Only two of them have shown moderate infection while the others were highly susceptible. The progress was slowed down to a considerable extent due to the absence of standard techniques for rapid screening against these diseases, and the obligate nature and racial variation of downy mildew fungus. Evidence is now available that downy mildew could be internally seed-borne also necessitating strong seed certification measures supported by detailed laboratory testing. The slow progress has also been due to the absence of off-season nursery facilities with adequate irrigation to rapidly advance the breeding material.

Inspite of the above handicaps the following interim measures have been found to be successful.

(i) An integrated strategy for control of downy mildew and ergot by management, change of date of sowing, seed treatment and spray of fungicides has been demonstrated. However, these methods will become less effective where the seed-borne infection is very high. A standardised procedure for testing against ergot is yet to be developed. The bio-chemical basis and the genetics of resistance is yet to be worked out.

(ii) The acceleration of the breeding programme has resulted in the identification of J 934, a partial dominant source of resistance to downy mildew, and the corresponding hybrid has shown only traces of infection in the co-ordinated trials. This hybrid was recommended during the workshop in 1972 for release in the endemic areas of downy mildew. In the case of ergot, it has been possible to release one hybrid K 559 (HB-5) which is found to be relatively more tolerant than the earlier hybrids. Adequate stocks of these two hybrids are now available with the breeders.

(iii) A mutation breeding programme has resulted in the isolation of two male steriles during this season resistant to downy mildew. This material is being multiplied this year for replacing the existing female parent.

(iv) The programme conversion of West African resistant lines into male-steriles has reached an advanced stage.

(v) An interspecific fodder-hybrid NB-21 and a seasonal hybrid K 667 have also been recommended for release with better yield by 60 per cent over the available fodder types and 20 per cent superiority in nutritional quality, digestability and palatability. It is proposed to intensify this work in the Fifth Plan so that this material can be useful in dry farming areas.

It is proposed to strengthen the existing programme during the Fifth Five Year Plan by improving the technical support in the coordination unit, strengthening the research programme on diseases and new pests, physiology and biochemistry, chemical control of vectors of viruses of bajra and ragi capable of infecting other cereals, breeding for wide adaptation and stability in seasons of severe drought accelerating the testing procedures for resistance, seed multiplication of breeders nucleus material to ensure freedom from seed-borne pathogen, biochemical and the physiological mechanisms of resistance for supplementing the regular testing procedures and intensifying prophylactic and chemical control measures using indigenous material against shoot fly, midge and white grubs in the traditional areas of bajra cultivation.

Bio-chemical and physiological basis of resistance to drought and diseases need to be undertaken immediately. This programme will be initiated during the next phase by providing a bio-chemist and physiologist at some important centres.

Preliminary work on the nutritional quality of bajra has resulted in the identification of inbreds with 20% protein, 3% lysine and high methionine and good productivity. This material will be incorporated in the breeding programme. Simultaneous feeding trials and an examination of different protein fractions are also envisaged so that the protein content and quality are simultaneously taken care of.

Alternate use of bajra for processing baby foods, biscuits and bread manufacture, industrial use, poultry feed and animal feed will receive attention during the next phase, since the production of bajra has already surpassed the target of the Fourth Five Year Plan. The present study has indicated that the existing material has enough variability for such use.

The programme can be successfully handled with strong supporting measures for stability of male sterility, multiplication of disease-free nucleus seed and enforcement of purity and resistance at all levels of multiplications and renewal of breeders stock annually.

The agronomy of bajra into a system of crops in dry land areas and intensive agricultural areas with non-cereals has been initiated.

Pulses Research

The Co-ordinated Project on the Improvement of Pulse Crops (grain legumes) with an allocation of Rs 77.3 lakhs, made a beginning during the Fourth Plan period, but soon began to face the challenge posed by the high-yielding varieties of cereals and millets which started claiming priority over pulses in cropping patterns adopted by farmers. A gradual shrinking of the area under pulses makes the task of research workers on pulses all the more onerous if production of these valuable grains, the major source of protein in the Indian diet, is to fully meet the nutritional requirements of the country. The number of research centres in the co-ordinated project, viz. ten, has been found to be rather small. In many States, the set up for reseach on pulses was hardly existent when the coordinated project started. While rice and wheat had the benefit of research results secured in other countries, which helped the projects on these crops to make a rapid headway, pulses had no such coordinated project started while rice and wheat had the benefit. Besides, most of the States had done very little for the improvement of these crops. Therefore, the project on pulses had to start almost from scratch.

Even during the brief period that the co-ordinated project has been operating a number of varieties of different pulses of superior yielding ability have been identified as a result of tests with varieties bred earlier or coming out of the breeding work taken up by the project. Thus, Bengal gram Type 3 of Uttar Pradesh and C 235 and G 24 of Punjab have also come out as better yielding varieties. Urad T 9 of U.P. combines early maturity with a very satisfactory yield. Among the early maturing varieties of pigeon pea (arhar) which would mature before frost comes in December-January (which hits the crop badly in north India), are type 21, Ageti, Sharda and Mukta. They are suitable also for arhar-wheat rotation. In mung may be named the varieties Hyb. 45 and Pusa Baisakhi, in lentil varieties T. 35 and L 9-12 and in field peas T. 163.

When we consider the very large area (about 21 million hectare) which pulse crops occupy in India, and the extreme urgency of increasing their production in face of competition posed by other rival crops, the need for much larger efforts and investments in pulse research becomes apparent. The number of centres in the coordinated projects needs to be increased from ten to at least twenty and they must be better staffed and equipped than at present. Among the items of research which need special attention are standardization of techniques for fertilizer application under dry farming conditions under which pulse crops are grown, development of integrated pest control schedules without which enormous losses are being caused to the crops, development of suitable bacterial cultures required for efficient production of particular pulse crops, fitting of short-duration varieties in multiple and relay cropping and breeding of varieties suitable as catch crops to replace monsoon fallows. Much remains to be done to investigate the possibilities of certain pulse varieties for conditions under which the cereal or millet crops now grown give extremely low yields and under which much more profitable yields from pulses may be possible if the required agronomy is developed. Thus, Bengal gram, under moisture stress conditions under which wheat is grown in some parts of central India, giving hardly 6-7 quintals yield a hectare, may find these conditions ideal for giving two to three times this yield.

Therefore, it is proposed to expand the scope of research on pulse crops to develop intensive programmes of breeding, plant pathology and entomology, agronomy and microbiology at the existing and several additional centres and to develop a large programme and seed multiplication of the improved varieties to ensure that the protein deficiency which faces the nation is banished for all times.

Cotton Research

The All India Co-ordinated Cotton Improvement Project was sanctioned from 1.4.1967. This project which was originally sanctioned up to 31st March, 1971 was extended to be co-terminus with the Fourth Plan period, i.e. 31st March, 1974. The total sanctioned outlay for the project was Rs 122 lakhs during the Fourth Plan Period. The object of the project was to evolve high-yielding varieties of cotton belonging to the different fibre length groups with in-built resistance to some of the pests and diseases like boll worms, jassids, black arm disease of cotton, etc.

During the mid-term appraisal conducted in 1971 it was felt that the project needed to be strengthened by way of additional centres, extra scientific personnel and physical facilities. The Ministry of Finance, therefore, sanctioned an additional amount of Rs 15 lakhs towards the strengthening for the years 1972-73 and 73-74. Under this strengthening four new centres were established and the centres at the Regional Research Station, Coimbatore, Indian Agricultural Research Institute, New Delhi, Agricultural Research Station, Surat, Ludhiana and the Cotton Technological Research Laboratory, Bombay, were strengthened by adding scientific staff. In addition, a proposal to take up on an intensive basis evolution of drought-resistant strains of cotton suited to the rainfed areas of the country has been very recently concurred in by the Ministry of Finance. The estimated outlay for the entire cotton programme during the Fourth Plan period comes to about Rs 137 lakhs.

Out of the total sanctioned grant of Rs 137 lakhs for the Fourth Plan period a sum of Rs 8.20 lakhs has been so far spent under the project.

Important Achievements

During the implementation of the project significant results have already come out. Higher-yielding varieties belonging to the different fibre group lengths have been released for cultivation. The present annual consumption of cotton by textile mills in India is around 64 lakh bales out of which the country has been importing, on an average, 8 lakh bales during the past five years. It is observed that the bulk of the cotton imported falls under the category of 1-1/16″ to 1-3/16″. With the results of research that have become available from the All-India Co-ordinated Project it is possible now to step up the production of cotton within the country in the above staple length categories and completely replace the country's imports from the U.S.A. The varieties and technology for increasing production of these categories are available.

The varieties and agronomic practices and crop protection techniques for increasing cotton production are now available for the major cotton growing tracts. The yield data from the farmers' fields in the State sponsored package of practices as well as the Indian Cotton Mills' Federation have proved that much higher yield of cotton than what has been obtained at present is likely to be possible if the scientific breakthrough can be converted into a production breakthrough.

The Union Department of Agriculture on the basis of the above data and results have initiated an intensive district programme in cotton modelled on the IADP for foodgrains.

By the end of the Fourth Plan it is anticipated that high-yielding varieties of cotton suitable for growing under moisture stressed conditions would become available. Intensive efforts are being made to identify American upland cottons which have better yield potential that can be grown in the dry areas. Success has already been seen to certain extent in the release of varieties like Bharati for the southern dry tracts and Buri 147 and Reba B-50 for the Central region. Higher yielding, higher spinning varieties of cotton would also become available for the northern irrigated cotton areas which are yet to make a yield and improve quality in their cotton products.

Oilseeds Research

This project was also sanctioned originally from 1.4.1967 and was later extended up to the 31st March, 1974. The approved outlay for the All-India Co-ordinated Oilseeds Improvement Project during the Fourth Plan is Rs 150 lakhs. Sixteen main and 12 sub-centres are operating under this project. The project as sanctioned originally took up research on linseed. Later on one main Centre was added to take up research on safflower. The objective of the above project was to evolve high-yielding varieties of oilseeds with a shorter duration with built-in resistance to some of the important pests and diseases that afflict these crops. During the mid-term appraisal, it was found that the scope of the project needed to be further expanded to cover the other oilseeds like sunflower, niger, safflower, etc. The above crops become very significant as they possess a very good quality oil in addition to their being suited for the rainfed areas of the country. It was further felt that certain basic problems relating to groundnut which form 60% of the total oilseed production in the country needed to be taken up urgently, if a *per se* production of groundnut was to be increased within a short period. The Ministry of Finance had, therefore, sanctioned an additional sum of Rs 10 lakhs for intensifying the above research programmes on groundnut. Under this programme the following items of research are proposed to be taken:—

1. Improved methodology for early evolution of high-yielding strains.
2. Physiological studies on drought resistance, dormancy, etc.
3. Microbiology.
4. Aflatoxin problem.
5. Biological control of white grub and virus diseases.
6. Crop-weather effects on groundnut cultivation and
7. Biogenesis of oil.

As regards the additional programmes relating to safflower, sunflower and niger, it was decided to utilise the savings under the All India Co-ordinated Project which had accrued due to the late starting of the project during the Fourth Plan period. Under sunflower 4 main centres and 16 sub-centres would be taking up research needed to back up the development programme launched by the Department of Agriculture. Four centres each would be devoting their research efforts in the crops, niger and safflower during the Fourth Plan priod. The total outlay for oilseed research during Fourth Plan works out to Rs 165 lakhs.

Achievements

The All-India Co-ordinated Project on Oilseeds Improvement, though a little late to start, has already given sufficient information for boosting oilseeds production in the country. Significant mention can be made of the evolution of groundnut varieties (bunch types) like J-11, AH-1192 and KG. 61-240, which are capable of giving more than 4 tonnes per hectare yield coupled with 50% and above oil-content and about 21 days of dormancy. These varieties are being multiplied for being introduced in a development programme. Researches taken up on groundnut have indicated that there are areas of higher productivity and lower productivity. Agronomic and plant protection schedules to boost yields under both these conditions have been worked out and are ready for use in a meaningful development programme.

Castor

Under castor, short-duration varieties/hybrids have already been released for cultivation. Mention can be made of Aruna, GCH-3, SA-1 and SA-2 which mature in a period of 150 to 160 days with an average yield of about 10 to 15 quintals. Significant areas have come under these varieties/hybrids. In the other oilseeds, higher-yielding varieties have been identified and are now in the final stages of testing. In brassicas a shorter duration variety Suphala has been released for cultivation. Among the newer oilseeds, the suitability of sunflower for Indian conditions has been established beyond doubt. Areas and seasons suitable for growing the imported Russian strains of sunflower have been drawn up and have been passed on to the development agencies for taking up a programme.

All the varieties have shown photoinsensitivity and have done well in all representative locations in the country in both the seasons and under irrigated as well as non-irrigated conditions. At several locations, seed yields are comparable to the yields obtained in the U.S.S.R. and other countries. Under unirrigated conditions, an average of 1413 kilograms per hectare was obtained at Digraj (Maharashtra) with only 75 mm, rainfall during crop growth and 1352 kilograms per hectare at Jalgaon with 283 mm rainfall. It is observed that yields as high as 3207 kilograms per hectare were obtained from an irrigated kharif crop at Coimbatore. In the northern states, rabi and spring summer crops have done well. In the states of Maharashtra, Mysore and Tamil Nadu, better results have been obtained in kharif.

Only exploratory work has been done on the agronomic aspects which forms the basis of the presently recommended package of practices. The standardised packages of practices for different agro-climatic conditions based on experimental data obtained from different agronomic experiments is expected to become available by 1974.

Data have to be collected to establish how far sunflower can replace advantageously the traditional rabi or kharif oilseed and other crops in different parts of the country. In view of the low prices for good grains such as Sorghum, bajra and maize, farmers are in search of an alternative and more remunerative crop to replace the millets. Sunflower plant, due to its characteristic growth habit (single stem and medium height in commercial oil-yielding varieties) may well adjust with several kharif and rabi crops as an inter crop. Data on the above aspect may also emanate out of the Coordinated Project by 1974.

Research on safflower and niger is expected to start shortly.

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Jute Research

An All-India Co-ordinated Project for the Improvement of Jute has been sanctioned from 1.4.1967 and has been extended up to 31st March, 1972. The total outlay for the project is Rs 48 lakhs. Eleven centres are functioning under the project. Unfotunately, this project has not been able to make much headway as the centres located under the State Governments of West Bengal, Assam, and Orissa have not been able to recruit personnel sanctioned for the project. This has been done only recently. This project deals with jute and other allied fibres like mesta, sisal, sunnhemp, ramie, etc.

Under the All-India Co-ordinated Jute Improvement Project new varieties of jute both *capsularis* and *oliterius* have been evolved and have been recommended for general cultivation. During the year 1971, variety JRC 7447 has been recommended for general cultivation initially in Orissa and Nowgong areas. Variety JRO 7835 was also recommended for release in the Gangetic belt of West Bengal, Orissa and Bihar. But these varieties have been found to do very well under irrigated and rainfed conditions.

A new sunnhemp variety (Chindwara) has been recommended for areas in Madhya Pradesh where soil pH is around 6.5 Another variety known as K-12 yellow has been released for the Pratapgarh and Varanasi belt. A mesta variety AMV-1 was recommended for all the areas along and below the latitude of 20° North. Ramie varieties like R. 1452 have been found suitable for north-eastern India. Sisal variety Bamra-1 has been recommended for general cultivation. The release of the new improved varieties is expected to promote fibre production in the country.

Mixed cropping of jute and moong has been found to be very effective in various cropping patterns tried with the jute crop. Baisakhi moong was sown roughly three weeks before jute sowings. The moong is harvested at a time when jute starts forming the canopy of its own. It has been observed that the growing of moong benefited the jute crop.

On the technological side, studies have indicated that the jute mill waste could be utilised by mixing with rubber latex alone or in combination with the formaldehyde resin to produce non-woven fabrics of good feel, pliability and resistance to water. This could be bleached, dyed and printed with the colour design. It has also been observed that Sisal leaves and pulp could be utilised for the extraction of Hecogenin which is of considerable pharmaceutical value.

Sugarcane Research

An All-India Co-ordinated Research Project has been sanctioned during the Fourth Plan period for taking up research on sugarcane at a cost of Rs 40 lakhs during Fourth plan period. Seven main centres and 7 sub-centres have been located under the project. This project was sanctioned during 1970. Under this project the Indian Institute of Sugarcane Research, Lucknow and the Sugarcane Breeding Institute, Coimbatore, were strengthened in addition to the centres located at the universities and state Departments of Agriculture:—

As the project was sanctioned in late 1970 and as it takes almost an year for the full implementation of the staff to join, it started functioning in full swing only from 1972. It is anticipated that research results on the following aspects may become available.

1. Early maturing high-yielding canes
2. Suitable agro-techniques both for the main and ratoon crop
3. Companion cropping schedules for the different regions.

Sugarbeet Research

An all India Co-ordinated Research Project has been sanctioned from 1970 for the improvement of sugarbeet cultivation in the country. The estimated outlay for the project during the Fourth Plan period is Rs 29 lakhs. Four main and 4 sub-centres are operating at present under this project.

A review of the on-going programmes indicating the need for cytological work in the sugarbeet crop to facilitate seed production was made. A unit has now been sanctioned at the Indian Institute of Sugarcane Research, Lucknow for taking up the work. Another unit to study the micronutrient requirements of this crop has also been sanctioned at the Lucknow University. As these projects were sanctioned in late 1970 the centres have started functioning in full swing only from the later part of 1971.

Achievements

The work done at these centres has already indicated the possibility of growing of sugarbeet crop during the rabi season (October to May) in the subtropical regions of the country. It has also been noted that sugarbeet can be combined with sugarcane. Areas in west Uttar Pradesh, Haryana, Punjab, Rajasthan, Deccan Canal area in Maharashtra have been found to be suitable for this new crop. Varietal trials conducted in these regions have shown that varieties like Ramonkoa and Magnapolly and Resistapolly have been found to do well under Indian conditions. Efforts to produce seeds cf sugarbeet within the country have proved successful. It is anticipated that seed production to meet the internal requirements would become possible locally by the end of 1974. Optimal agro- and plant-protection techniques to grow an ideal crop of sugarbeet under the subtropical areas of the country would also become available by the end of the Fourth Plan period.

Tobacco Research

An All India Co-ordinated Research Project for the Improvement of Tobacco was sanctioned from 1970 at a cost of Rs 25 lakhs to the Council during the Fourth Plan period. Under this project 4 main centres and 5 sub-centres are operating at the moment. The project was sanctioned in late 1970 and as it takes almost an year for recruitment of staff at the State and University Centres due to administrative procedures, this project has started functioning during current year in full swing.

It has been noticed during the implementation of the programme that certain fields of research needed to be intensified urgently. One of the most important was work relating to the evolution of nematode resistance strains of tobacco. This has assumed great importance as it has become evident that very good quality of FCV tobacco can be grown in light soil areas, which have not been hitherto used for tobacco cultivation. As the light soil areas are infested heavily with nematodes, this line of research was found very essential to promote the programme of FCV tobacco cultivation in the light soil areas. Accordingly, the Co-ordinated Project was strengthened by the addition of nematological staff both at the Anand and Bangalore centres under the project. It is further noted that the light soil areas in Mysore State which had great potential in increasing the production of good quality FCV tobacco, four more field centres were also sanctioned under the Bangalore main centre. Export of FCV tobacco necessitated the analysis of pesticide residues on the tobacco leaves. Provisions for such an analysis, which was not hitherto available, are being created at the CTRI, Rajahmundry. The project is at the moment operating at 9 centres.

Achievements

The project started functioning in full-strength during the late part of 1971. Two strains of FCV tobacco to have higher yield and better quality (Kanak-prabha and Dandai) have been released for cultivation. Powdery mildew resistant lines and lines resistant to tobacco mosaic virus have also been tested in endemic areas. It is anticipated that resistant lines would become available for cultivation by the end of 1974. The agro-techniques required for growing a good quality crop of FCV tobacco in the light soil areas is likely to emerge due to the investigations now being taken up under the project by the end of the Fourth Plan period.

Soybean Research

An All India Co-ordinated Project was sanctioned during the Fourth Plan period at a total cost of Rs 18 lakhs to the Council.

Although soybean is not a new crop to India, the improved high-yielding varieties of soybean which were imported from the U.S.A. are new to the environment of this country. During this short period of four years much progress has been made in the field of soybean research. Varieties suitable for cultivation in the different parts of the country have been identified and through organised production marketing and utilisation programmes, soybean can make substantial contributions to both our immediate oil and protein needs.

Plantation Crops Research

The country is witnessing to-day, what is popularly known as the Green Revolution in the case of food-grain crops, due to the systematic application of improved agricultural technology to crop production. Plantation crops contribute significantly to the economy of the nation by earning valuable foreign exchange, by supporting a number of industries, and serving as subsidiary food material. In the case of these crops, which are by and large perennial in nature, it is all the more important to bring about a similar revolution as in the case of the staple food crops.

The planning for plantation crops research in the country is thus based on the following broad considerations:

1. To identify problems limiting production.
2. To tackle the problems on a long term or short term basis, in a co-ordinated, multi-disciplinary way.
3. To meet problems limiting export of plantation crops.

During the Fourth Five-Year plan, a significant development was the establishment of a Central Plantation Crops Research Institute at Kasargod, by bringing into one organisation the many dispersed research centres working on coconut and arecanut crops. This has led to pooling of resources, avoidance of duplication, better control over work and exchange of ideas.

Two All-India Co-ordinated Crop Improvement Projects, viz.

1. All India Co-ordinated Coconut and Arecanut Improvement Project, and
2. All India Co-ordinated Cashewnut and Spices Improvement Project have been launched.

All-India Co-ordinated Coconut and Arecanut Improvement Project

Outlay	Rs 54 Lakhs
No. of centres proposed	13
No. of centres established	13
Physical target	Amount likely to be utilised in full

All India Co-ordinated Spices and Cashew Improvement Project.

Outlay	Rs. 25 lakhs
No. of centres proposed	11
No. of centres established	11
Physical target	Amount likely to be utilised.

Besides the above, a scheme for strengthening of the Central Plantation Crops Research Institute, Kasargod, has been formulated at a cost of Rs 45 lakhs. Under this scheme, it is proposed to strengthen certain disciplines which are at present weak and to take up new items of work. It is also proposed to start investigations on oil palm and to establish an affiliated unit for work on spices. It is hoped that this scheme would be in full operation well ahead of the end of the Fourth Five-Year Plan.

A number of national production problems have been identified. These have a stalling effect on production. These are :

1. Coconut wilt disease
2. Yellow leaf disease in arecanut
3. Cardamom 'mosaic'
4. Pepper wilt
5. Soft rot in ginger
6. Low yields
7. Problems brought about by erosion and lowered fertility
8. Poor fruiting in cashew
9. High flower and fruit drop in cashew
10. Long pre-bearing season in the case of perennial crops

Investigations have been taken up on the problems outlined above as also on other production problems such as pests and diseases, nutritional needs, etc. In coconut, it has been shown that the Natural Cross Dwarf and the Tall × Dwarf hybrid show a good amount of field tolerance to the wilt disease, as compared to the local Tall. Alteration in the daylight conditions of coconut seedlings appear to bring on earlier flowering. In arecanut, a high-yielding variety has been brought up for release. This variety is likely to make a significant improvement in production in the years to come.

In cashews, a number of hybrids are under study and some have flowered in about two years from seed. In pepper an improved hybrid Panniya-1 has already been released and observations on other hybrids are continuing. In cardamom, investigations are in progress to tackle the serious problem of virus disease.

The investigations so far made have led to indications as to the future programme of work to be undertaken in the next Five-Year Plan. These are broadly:

1. Irrigation technology to find the optimum water needs to avoid wastage and to increase yields.
2. Radio tracer studies with emphasis on fertilizer application to bring about economy in fertilizer use.
3. Development of improved tools.
4. Evolving integrated pest and disease control programmes, to bring about economy in chemicals and labour.
5. Studies on mechanisation of cashew industry.
6. Wet milling of coconut to improve oil yields.
7. Foliar nutrition particularly in cashew to put up yields for a crash programme.
8. Forecasting pest and disease occurrence.
9. Reduction of pre-bearing period.

SOIL, WATER MANAGEMENT, AGRONOMY, ENGINEERING AND NATIONAL DEMONSTRATION

1. Soil and Water Management Research

1.0 *Introduction.* Water Management is a neglected technology in the country. Injudicious water use results in inefficient use of irrigation water and poses post-irrigation problems of soil salinity, waterlogging, etc. About 36 million hectares are now under irrigation and efforts are being made to increase the same to 90 million hectares. Investments on irrigation are costly and maximum returns per unit of irrigation water used, should be aimed at, to get back the money's worth. Prior to Fourth Plan, there was hardly any systematic research in soil-water management as related to modern agriculture. Recognising the gaps, the Council has sanctioned 5 coordinated research schemes for improving the efficiency of water use, apart from one coordinated project on dryland agriculture which caters to soil-water management under rainfed conditions. Besides, institutional research at Central Soil Salinity Research Institute, Karnal, Water Technology Centre, IARI, New Delhi, Central Arid Zone Research Institute, Jodhpur and the eight Soil Conservation Research Centres serve the cause of soil-water management, with Fourth Plan allocations.

1.1 *Progress.* There are five Fourth Plan schemes sanctioned in this field of research with a total plan outlay of Rs 266 lakhs. Of these, the schemes (i) on water management and soil salinity (plan outlay-Rs 110 lakhs) and (ii) New Cropping Patterns and Water use in selected commanded areas (Plan outlay-Rs 45 lakhs) were sanctioned earlier and are at different stages of implementation at 17 centres and 9 centres, respectively. The remaining 3 schemes namely, (iii) research on water management in high rainfall areas and temperate hill zones (outlay-Rs 64 lakhs), (iv) research on use of saline water in agriculture (outlay-Rs 30 lakhs) and (v) studies on design and construction of open and tubewells (outlay-Rs 17 lakhs) are new schemes, recently sanctioned. They have yet to implement the experimental programme. Under the scheme

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on water management and soil salinity, valuable information on water use of rice, wheat, berseem, groundnut and cotton have been obtained. In rice, tillering to flowering is the critical period when water stress reduces the crop yield. Soil moisture, maintained at field capacity till maximum tillering, followed by 5 cm submergence in medium textured red soil in Hirakud Command, is found to be as efficient as continuous submergence. In heavy black soils of Tungbhadra command, with high water table in kharif, maintenance of moisture regime from saturation to hair cracking throughout the crop growth, gave as much yield as with continuous submergence, but saved more than 50% of irrigation water. In wheat, irrigation scheduling has been successfully done at Ludhiana, Jobner and Siringupa, based on ratio of 0.75 to 1.0 between irrigation water and US open pan evaporimeter value (60 mm irrigation water after 80/60 mm OPE value). For Hampi cotton in Tungbhadra command, 2 pre-flowering and 4 post-flowering irrigations are found to be adequate in black soils. Much more remains to be done and more crops are yet to be studied. In case of new cropping pattern scheme, due to phasing of centres 2 centres have been sanctioned as recently as 1971-72 and programme is yet to be implemented. At other centres, research is in its initial stages to obtain any confirmed results.

1·2 *Position and Projection.* Usual delay in providing basic research facilities and recruitment of suitable scientists has caused a lag in implementation of full programme of research. Also the non-availability of special equipment for moisture measurement handicapped the progress of the scheme. As such, the anticipated expenditure on the first two schemes namely water management and soil salinity, new cropping pattern scheme as also the scheme on open wells/tubewells, is expected to be Rs 142 lakhs as against the plan outlay of Rs 172 lakhs. In view of the importance of these schemes in increasing use-efficiency of irrigation water in crop production, they will be continued in the Fifth Plan period, hopefully, with an increased outlay of Rs 2.5 crores.

1·3 *Dry Farming Research.* About three-fourth of the country's cultivated land raise rainfed crops. Dryland agriculture is unstable and is a gamble with the monsoon. To improve production under dryland conditions, an All-India Coordinated Research Project on Dryland Agriculture has been implemented at 24 centres. After the initial delay in staff recruitment and in providing basic research facilities, the programme has now been implemented at all centres. Basic concepts under test are mostly on screening for suitable crop variety, crop substitution, adjusting crop season with climatological parameters, use of fertilizers and plant protection measures, conservation of rain water, optimum use of conserved water, etc. Within the short period, sunflower and safflower appear to be very promising for black soils, compared to the existing oilseed crops. HB-3 bajra and CSH-1 jowar are performing better under rainfed conditions. Soil application of fertilizer has acted as an insurance against drought and increased crop yields.

1·4 *Position and Projections.* The scheme came into operation in October, 1970. In view of the time lag in recruiting staff and providing research facilities at all centres, the objectives of the scheme will not be fully realised during the Fourth Plan. An anticipated expenditure is, however, maintained at the level of increased outlay of Rs 178 lakhs as a sizeable amount is to be spent on land, buildings, equipment and other non-recurring items. In view of the essential nature of the scheme, relating to vulnerable section of the farming community, this needs to be continued during the Fifth Plan period, hopefully with an outlay of Rs 2 crores.

2. Soil Productivity Research

2·1 Under the group of soil productivity research, four all India coordinated research projects, namely (i) investigation on correlation of soil test with crop responses, (ii) micronutrients of soils, (iii) measurement, evaluation and improvement of soil structure, and (iv) microbiological decomposition of organic matter in Indian soils under different climatic conditions, have been implemented as Fourth Plan schemes with a total plan provision of Rs 121 lakhs.

2·2 *Progress.* The technical programmes have been implemented at all centres under the four schemes on soil productivity research and valuable results have been obtained. The scheme on correlation of soil test with crop response has been in operation at 13 centres, five of which were sanctioned in 1970 as additional centres. Its programme aims to obtain research information to improve the prediction value of soil test and the use efficiency of costly fertilizers in crop raising. Nutrient needed to produce one quintal of grain of high-yielding variety of rice and wheat has been determined. Rice needs 1·78 kg nitrogen, 0·88 kg P_2O_5 and 1·87 kg K_2O while that of wheat is 2·36 kg nitrogen, 0·82 kg P_2O_5 and 2·1 K_2O for every quintal of grain to be produced. On the basis of these values, and using the percentage contribution of these nutrients from added fertilizer and soil, yields of rice and wheat have been successfully targetted within 10 per cent error. The maximum and economic responses to fertilizer in important soils of the country have been worked out for rice, maize, jowar and bajra. The scheme on micronutrients has been implemented at eight centres; the eighth centre, however, was sanctioned in 1970 as an additional centre. Under the scheme, deficiency symptoms of rice, wheat, jowar and maize have been obtained. Coloured plates are being prepared for general use. Analysis of numerous soil samples for micronutrient content has revealed widespread deficiency of zinc in the country, specially in the northern alluvial plains of Punjab, Haryana, U.P., Bihar, in several districts of M.P., A.P., Tamil Nadu and Gujarat. Where zinc supply from soil is moderate to low, a general recommendation is made to apply 20-30 kg zinc sulphate in addition to NPK for obtaining best yields of crop varieties, highly susceptible to zinc deficiency. High-yielding varieties of rice, wheat, and maize have been screened for their relative susceptibility to zinc deficiency. The research programme under the soil structure scheme has been undertaken at nine centres, the 9th centre being the additional centre sanctioned only in 1970. Results obtained under the scheme have shown that the bulk density of soil, greater than 1·55 gm/cc, restricts root penetration and plant growth in heavy textured soils. Sub-soiling has increased yield of wheat at Delhi, of maize at Hissar and of jowar at Kota. In general significant rise in yield is obtained with heavy application of straw as well as by addition of non-edible cakes like 'neem' cake, 'mahua' cake, 'karanj' cake, etc. The scheme on decomposition of organic matter was implemented at 8 centres. The rate of decomposition of organic matter in different problem soils like saline-alkali soils, acidic soils, heavy clay soils, etc. has been determined. Microbial population in major soils has been enumerated. The study of interaction between pesticides and microflora has shown that application of 1 ppm of Aldrin and Thidane proved toxic to the microbial population up to 8-10weeks after application, in Kanke acid soils and Patna heavy clay loan. Addition of high doses of organic matter to these soils found helpful in detoxification of pesticide residues.

2·3 *Position and Projections.* As an essential programme of research in supporting the new strategy of crop production, these four schemes have been undertaken with a Fourth Plan outlay of Rs 121·00 lakhs. On demand from States, few additional centres under the scheme on soil test-crop response correlation, micronutrients and soil structure were sanctioned in 1970. At all centres, there has been considerable delay in providing the basic research facilities and recruiting suitable trained staff. Special equipment for dependable but speedy analysis of soil and plant samples, like atomic absorption spectrophotometer, moisture measuring instruments like pressure membrance apparatus, pressure plate, neutron probe, etc. are not easily available and thus, handicap the progress. In case of the micronutrient scheme, efforts have succeeded in procuring four units of atomic-absorption spectrophotometer from abroad in 1971-72, with arrangements to procure another four units during 1972-73. In view of these difficulties, the research envisaged under the scheme will not be completed during the Fourth Plan period. *In consequence, therefore, the anticipated expenditure of these 4 schemes at the end of Fourth Plan is expected to be about Rs 104·07 lakhs as against the Fourth Plan outlay of Rs 121 lakhs.* The research schemes on productivity research are vital in the general drive for increasing agricultural production in the country. Soil testing is increasingly being adopted for efficient fertilizer use. The crop response correlation for all the major soils and important crops need to be obtained. Similarly, the soils in the country have to be delineated for their micronutrient deficiency. The screening of all important crop varieties needs to be completed to identify the susceptible ones to recommend application of micronutrients, lest the crop yields are restricted. Studies on biodegradation of pesticides which have since been initiated, have to be intensified in view of the pollution hazards apprehended from intensive and increasing use of agriculture chemicals. In recognition of these facts, it is important that the four schemes implemented during Fourth Plan, need to continue during Fifth Plan, hopefully, in an expanded and strengthened way, so as to provide at least one centre in each state/territory. For the purpose, a Fifth Plan outlay of about Rs 2.5 crores may be needed.

3. Agronomic Research

3.1. Co-ordinated Project on Long-Term Fertilizer Experiments

With a view to studying the cumulative effects of fertilizer and biocidal chemicals over years on soil and plant, a coordinated project on Long Term Fertilizer Experiments was sanctioned by the Ministry of Finance at an estimated cost of Rs 5·00 lakhs for a period of five years from 1969-70. During 1970-71 only one centre at the Indian Agricultural Research Institution New Delhi could be established. By March, 1972, ten centres were established at Pantnagar, Ranchi, Barrackpur (West Bengal), Bhubneshwer, Coimbatore, Bangalore, Hyderabad, Jabalpur and New Delhi.

In 1972-73 one more centre will be established in Himachal Pradesh University, Palampur. Major crops like paddy, wheat, maize, jowar, bajra and legumes are being grown adopting recommended multiple cropping patterns of high intensity for the representative region using necessary production inputs like fertilizers, biocidal chemicals, irrigation, etc. Changes in soil properties including physical, chemical and biological are being studied at pre-determined intervals. Effects of continuous application of fertilizers, pesticides, etc., on the plant growth and productivity and land in long run is also being determined in well-designed long term experiments. Data will be assembled every year. Cumulative effect of continuous cropping with high intensity crop rotations in conjunction with large dose of inputs will also be evaluated periodically.

This project has just started. No result of practical utility could be passed on to extension because sufficient period, say five years, will be required to assess cumulative effect. As this is the only project which proposes to monitor the changes in environment as a result of intensive cropping and heavy application of agricultural chemicals, it needs further intensification and strengthening both in terms of its objectives and financial layout during the Fifth Plan. In fact this is the type of studies which are included under Man and Biosphere Programme launched by UNESCO and research activities proposed by UN Conference on Human Environments.

3.2. All-India Co-ordinated Agronomic Experiments Scheme

This project started in 1950 with the expert advice of Dr A.B. Stewart. During different Plan periods, its objectives, scope and staffing pattern have evolved to the present state. Outlay for the Fourth Plan period is Rs 226 lakhs. The scheme has three main components with the broad objectives discussed in the following para, while in the Third Five-Year Plan the emphasis under this scheme was on developing fertilizer practices for tall varieties in the Fourth Plan the entire work is oriented to developing an agronomic technology for high-yielding varieties and specific to the local condition.

Replicated experiments are being done at 43 centres, with the broad objective of obtaining comprehensive scientific information on the individual, aggregate and cumulative effects of a number of factors, namely, fertilizers, irrigation and cultural practices in different soils under different climatic conditions. The relative efficiency of different nitrogenous and phosphatic fertilizers which are being produced or are projected to be produced in the country is also being studied. The experiments on multiple cropping on maximising the production per unit area of land and per year, are receiving special attention so as to evolve a technology suitable for different conditions.

Thousands of unreplicated simple fertilizer trials are being conducted in 50 districts on cultivators' fields with the high-yielding varieties to find out the best fertilizer combination for different soils and crops. Twenty of these districts are in the dry farming area. Last year 498 agronomic experiments were conducted at 43 research centres located in all States of the Union of India. In addition, eight simple fertilizer trials were conducted on the field of cultivators in 50 districts.

Technical Achievements

Historically this project provided the basis for making fertilizer recommendations in different parts of the country before the advent of high-yielding varieties. It will not be exaggeration to assert that the fertilizer use in the country started with the findings emanating from this project. It provides the basis for the yardstick of additional production due to various agronomic techniques. Lately the following results of practical utility have flown from this project:—

1. High-yielding varieties of different cereals performed better than the local varieties at native as well as at high soil fertility levels.
2. The response of different crops to balanced fertilization and expected net return per rupee of investment of fertilizer in different districts for different crops have been worked out. The areas responsive to the application of potassium and micro-elements have been delineated. It may, however, be appreciated that it is a changing position from time to time.
3. In different districts the correlation of crop response to phosphorus index of soil and expected net return per rupee of investment in fertilizer have been worked out for different varieties of high-yielding cereals.
4. Suitable multiple-cropping sequences for obtaining high grain yield have been worked out for different soils and climatic regions of the country.
5. For dry farming areas the magnitude of the response of crops to the application of nitrogen, phosphorus and potash and to moisture conservation practices are being studied.

Thus, this is one project through which broad spectrum of potential crop productivity and response to fertilizer use under conditions obtaining in farmers' fields have been worked out for the greater part of the country. This project, therefore, provides a very good support to the development needs of the Ministry of Agriculture.

The frequent transfer of staff during the Plan periods has created some problems in the efficient functioning of the project in some States. Specially the soil and plant analysis work of the project is weak. During the Fifth Five-Year Plan this part will need strengthening. Recently development of intensive farming system for small holders has also been brought under the purview of this project. During the Fifth Five-Year Plan considerable strengthening in this regard will also be needed. In fact, in future the project will need to work out suitable technology for all the districts and also evolve a package of practices suited for labour intensive, input intensive and also for dry farming conditions.

4. Agricultural Engineering

4.1. Zonal Research Centres

To create a suitable infrastructure for the agricultural engineering research, 17 research, testing and training centres for agricultural implements were set up in the different States during the Third Five-Year Plan. During the Fourth Plan, it was decided to strengthen two

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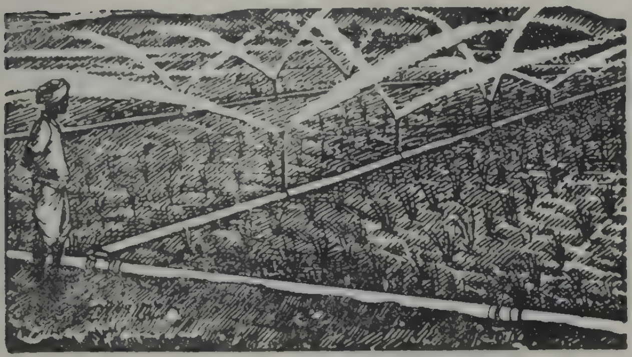

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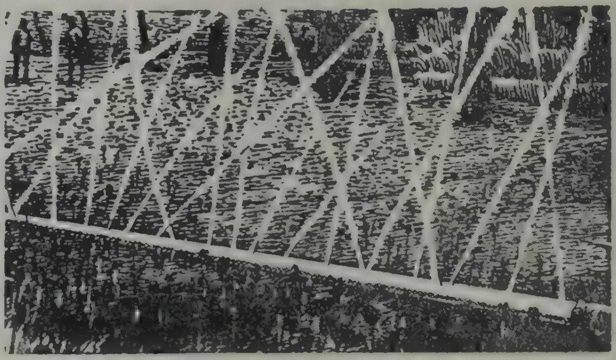

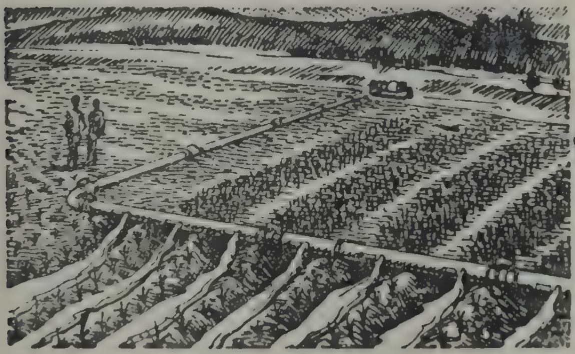

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of these centres at IARI, New Delhi and Coimbatore into Zonal Research and Design Centres for all agricultural implements and machinery suited to wheat and paddy zones in the North and South of India respectively.

Objectives. The main objective of this Scheme is to design, develop and test the implements and machinery for tillage, seeding, fertilizer application and processing and harvesting of various crops—dry farming, subsoiling and mulching devices suitable for different soils and machinery for land smoothening, ridging and bunding equipment for efficient water distribution and conservation.

The IARI Centre is also the coordinating centre for the scheme with two Senior Research Engineers and a complement of staff. The Coordinator with some staff is in position. At Coimbatore all the staff is in position. The buildings at both the centres are yet to be built.

At IARI, a wheat thresher, reaper, seed-cum-fertilizer drills and at Coimbatore, groundnut-diggers for power tillers and groundnut shellers have been developed.

Ten prototypes of IARI reaper have been made and evaluated at several centres. Field defects noticed are now being rectified. The Pusa wheat thresher has been released for manufacture.

Besides these two centres, it was also proposed to finance from the Cess funds of the IARI four research and testing centres at Ludhiana, Poona, Hyderabad and Mandi.

(i) The Ludhiana Centre has designed bullock drawn reaper, bullock drawn engine mounted reaper, front mounted reaper, self-raking reaper, potato and groundnut diggers and released them for manufacture.

(ii) At the Poona Centre, Tractor-bund-former, stubble-mulcher and anhydrous ammonia applicator have been developed.

(iii) The Hyderabad Centre has developed double-drum-thresher, and puddler. It is also testing power tillers.

(iv) At Mandi Centre, Tool bar frame for bullock power with attachments for ploughing, cultivating, pulverising and hand tools for hill areas have been developed and released for manufacture. In order to bring about effective coordination, the two schemes are being brought under the purview of the Coordinator at IARI.

4.2 Energy Requirements for Intensive Agricultural Production

The Scheme was sanctioned in September 1971 after clearance by the Planning Commission and Ministry of Finance at a cost of about Rs 12 lakhs. The participating institutions are Agricultural Universities—Ludhiana, Pantnagar, Jabalpur, Coimbatore and I.I.T., Kharagpur.

The main objective of the scheme is to investigate energy requirement for each soil agroclimatic region and for all operations from tillage to transport by using human, animal and mechanical power and electrical and fuel energy.

The Scheme will be coordinated by the Centre at the Punjab Agricultural University, Ludhiana.

Only a portion of the staff are in position at each of these centres. Equipment to a large extent has been purchased at all Centres excepting Coimbatore and field experiments have also been laid. The scheme started late and it is expected that it will make a good progress in the remaining two years of the Plan.

4.3. Engineering Aspects of Open Wells and Tubewells

The scheme was implemented at five centres—P.A.U., Ludhiana, Irrigation Research Centres at Roorkee, Baroda, Poondi and Osmania University, Hyderabad with a total outlay of Rs 17 lakhs.

The main objective of this scheme is to carry out Research with a view to improving the design and construction standards of open wells and tubewells and to find out ways and means of effecting economy in the construction and operation and maintenance of these.

The programme is under the charge of a Research Engineer supported by technical staff at each centre. All the staff are in position excepting the Research Engineer at Poondi. Coordination of the scheme is being looked into by Dr A.M. Michael of Water Technology Centre.

Specification for gravel pack has been made by Roorkee Centre. At Ludhiana, it was pointed out that the ratio suggested by Johnson for screens and gravel pack should range between 4 and 6. At Baroda, it was observed that it may not be desirable to provide artificial packing for coarse grained aquifers varying from 1 mm to 2·8 mm.

Studies are in progress on the relationship of diameter of the screen in relation to discharge and characteristics of aquifer. A pre-pack by bonding gravel on to a slotted pipe has been tested for strength and hydraulic efficiency.

At Baroda, an electric analog model to determine ground-water potential and re-charge of the right bank canal has been installed. The Hyderabad Centre is investigating the geology and hydrology of areas around Hyderabad, Palnad basin and Mahanadi area. Well inventories of over 100 wells have been collected.

A field study made at Ludhiana on the usefulness of having a battery of wells instead of independent wells, proved that it is economical to go in for a combination rather than having individual wells. Optimum thickness of the masonary for open wells was also determined. Radial drilling of open wells increases the discharge of open wells by about 33 per cent. Details from about 1700 failed and sick wells have been collected at Poondi and an analysis of the causes for the failure of wells was made. Such studies were also initiated around Hyderabad.

In conclusion it may be stated that there was some initial delay in recruitment of the staff due to administrative reasons. There is also an urgent need for providing a fast moving vehicle with jeep and trailer for carrying the test equipment from place to place.

4.4 Harvest and Post-harvest Technology

This scheme has been approved by the Planning Commission at a total outlay of Rs 46 lakhs and is awaiting the final clearance by the Ministry of Finance. This scheme would be operated at 10 centres of which the centre at IARI would be the Coordinating Centre. Its main objective is to study various aspects of post-harvest technology—stage of harvesting, techniques of processing, storing, drying, store grain pest problems, handling and marketing. The scheme will start during this year and for completing its objectives it has to be continued in the Fifth Plan.

4.5 Manufacture of Prototypes and Carrying out Pilot Projects

The scheme aims at creating facilities for fabrication of prototypes of implements and machinery designed at the two main research centres so as to make it available for large scale testing. It was approved by the Planning Commission and is yet to be cleared by the Ministry of Finance.

4.6 Prize Award Scheme

In order to develop the inventive talents of individual designers or inventors, the ICAR has implemented an *ad hoc* scheme for award of prizes for outstanding contributions in the design of implements. The total cost of the scheme is Rs 2.5 lakhs for five competitions.

A paddy transplanter designed by Shri R.N. Mohapatra from Bhubaneswar has been selected for the first award.

5. National Demonstrations

5.1 Background and Objectives

The national demonstration programme was started in 1965 on a small scale for the proper demonstration of new technology of high-yielding varieties to farmers. For the Fourth Plan the project was widened in scope as well as in strategy. It became the main programme for transfer of technology of maximising production per unit area per unit time, in 100 districts on an intensive scale. In every district Subject Matter Specialists were provided. Every National Demonstration field is to be used as a mini university for the training of farmers.

5.2 Achievements

During the year 1965-66 and 1966-67, National Demonstrations were laid out primarily as single crop demonstrations and thereafter they have become multi-crop demonstrations.

The number of demonstrations exceeding the targetted yield of 9 and 11 tonnes/ha for 2 or 3 crops respectively have been gradually increasing since the inception of multiple cropping in National Demonstrations. The percentage of demonstrations exceeding the targetted yield for 1967-68 was 55 whereas it is 60% in 1970-71 with the increased number of demonstrations.

In multiple crop rotations, given above, it is noticed that wherever paddy was rotated with paddy or wheat the yield exceeded the target of 9 or 11 tonnes per hectare for 2 or 3 crops respectively. In rotations having jowar, maize or bajra, only low percentage of farmers could get the targetted yields, which shows the poorer than expected performance of high-yielding varieties of jowar, bajra and maize. Invariably in 3 crop rotations targetted yield of 11 tonnes/ha was achieved in all the National Demonstrations, but the average yield was no better than 2 crop demonstrations, showing there by that as a practical measure two crops in a year is a good strategy.

As regards the performance of individual crops since the initiation of National Demonstrations programme, the performance of paddy and wheat have been excellent. The targetted yield of 4·5 tonnes achieved in various crops show that so far as paddy and wheat are concerned the percentage of cases with more than targetted yield have gradually increased and are below 80-90 per cent, whereas in case of maize and bajra the percentage cases above the targetted yield are rather low. The position of jowar is also similar. It shows rather poor performance of the varieties of bajra, jowar and maize, poor germination, greater susceptibility to diseases and pests and greater susceptibility to poor water management.

5.3 Linkage with Farmers' Training

The National Demonstrations have also proved as excellent centres for farmers' training or for transfer of technology to the farming community. On an average 2 to 3 Field Days have been organized at each National Demonstration and 30 to 40 farmers have visited them on every such occasion. From the information received from various states farmers have been evincing increasing interest in National Demonstrations.

5.4 Coverage Under National Demonstrations

The National Demonstrations Programme has already been undertaken in 86 intensive districts out of 100 such districts to be covered by the end of Fourth Five-Year Plan. In most of the districts Subject Matter

Specalists in Agronomy, Soil Science, Agricultural Engineering and Plant Protection are in position.

It has been reported that by now in 75 intensive districts Co-ordination Committees at State/District levels have been formulated to guide the National Demonstrations Programme.

5.5 Bottlenecks in National Demonstrations Programme

The following few bottlenecks have been experienced in the National Demonstrations Programme since 1967.

(i) The slow progress of appointment of the Subject Matter Specialist, and frequent transfers and non-availability of some Specialists like engineers has affected the progress of the scheme. So far only 34 Specialists in Agricultural Engineering have been appointed in 75 districts and there is great difficulty of finding experienced and well trained Specialists in Agril. Engineering for other districts.

(ii) Non-availability of vehicles has also severely affected the programme. So far only 40 vehicles have been available and 60 more are yet to be purchased.

(iii) Inadequate Travelling Allowance and Contingent funds are handicapping the programme.

(iv) Although National Demonstrations are being conducted in the intensive districts having Farmers' Training and Rural Radio Programme, yet the experience shows that where both the programmes are with the same agency the linkage is excellent.

ANIMAL SCIENCES

In the Fourth Five-Year Plan research effort in Animal Sciences is being mainly directed towards developing strains of different species of livestock with higher productivity and improvement of animal health so as to provide economic returns to the farmers and to increase the availability of animal products in the country. The research programmes are undertaken at the Central Institutes, Agricultural Universities and State Research Stations. 32 multi-disciplinary coordinated research projects in various disciplines of Animal Science have been taken up during the Fourth Five-Year Plan. These have resulted in considerable strengthening of research in the field of Animal Science in the country and encouraging results under many of these are coming up.

The total allocation agreed to for Animal Sciences research projects/institution during the Fourth Five-Year Plan is Rs 20.62 crores out of which Rs 11.64 crores are for the coordinated research projects in various disciplines of Animal Sciences. Subsequently, a sum of Rs 1.08 crores additional amount has been agreed to for the Animal Sciences research institutes raising the total allocation of Rs 21.70 crores. The progress of the important coordinated research projects in Animal Sciences research which has been achieved and is expected to be reached by the end of the Fourth Five-Year Plan period is as under.

Animal Breeding

Cattle

With a view to evolving high milk-yielding cross-bred dairy animal adapted to tropical and sub-tropical conditions, a comprehensive coordinated project envisaging scientifically controlled programme of cross-breeding local cows with 3 exotic dairy breeds namely Jersey, Holstein Friesien, and Brown Swiss has been taken up. The object is to evolve a breed of dairy cattle by synthesis of Indian exotic breeds which will be suitable for specialised dairy farms, the intensive milk production areas and other areas of commercial milk production. The cows so evolved will have minimum milk production of 2000 kg of milk per lactation with a herd average production of 3200 kg and a fat test of not less than 3.5 per cent. Besides this, cross-breeding research is being continued at other research centres. The coordinated project is operating at 5 centres at Izatnagar, Hissar, Jabalpur, Rahuri, Lam/Chintadevi (A.P.). In addition, the cross-breeding project at Harringhata has also been merged with this project. At all the centres foundation breeding stock has been obtained in required numbers as far as possible. Some more is to be added to make up the required number. The cross breeding programme with frozen semen has been initiated. At various centres cross-bred animals are coming up. It is observed that the cross-bred mature at 18 to 21 months which is a significant advancement over the period of maturity in Indian cattle. At Harringhata about 400 cross-bred calves out of three exotic breeds have been produced which have been found to mature at an age much earlier than the Haryana animals.

Buffalo

A Project for improvement of buffaloes through selection and breeding has been undertaken at Punjab Agricultural University, Ludhiana, NDRI, Karnal, the UAS Bangalore (Dharwar) and at Udaipur. At all the centres work has been initiated and foundation stock has been obtained and breeding programme has been taken up.

Sheep

Two co-ordinated projects on sheep with a view to improving wool quality and mutton quality have been taken up. The project on sheep for wool has the object of evolving fine wool breeds of sheep suitable for major wool producing areas of the country with the expected genetics potential of 50 kg of body weight and yielding about 2.5 kg of greezy fleece of 58's to 64's quality.

Different combinations of crosses of the local breeds with exotic breeds are to be provided to test their performance for the growth, production of wool and its quality and reproduction efficiency. The units of the projects and Malpura and Tal (M.P.) have started. The construction of buildings produced in the project is to be taken up soon. Foundation stock of Chokla and Nali breeds has been purchased. Russian rams for cross-breeding have been obtained and the rams of other exotic breed namely Rambouillet, are expected by the end of this year.

The project on sheep for mutton has the object of evolving new breeds of mutton type sheep suitable for different agro-climatic regions of the country having a high genetics potential so that animals attain a body weight of 30 kg at six months of age. Various combinations between exotic and indigenous breeds will be tested for production of meat, economics of feed conversion as well as reproduction efficiency. At the 3 centres where the project is functioning foundation stock of indigenous breeds has been obtained and the exotic stock is also expected to be available soon.

Though not strictly under the above projects at Malpura, research to support the programmes of the above project is being continued. With a view to augmenting the productivity of the sheep and for taking up the large scale artificial insemination, it has been found that lambing can be increased by 40 per cent with the use of hormones. At this place cross-breeding of local chokla sheep with exotic Rambouillet sheep has been found to produce first generation crosses which have substantial higher wool production per animal as well as wool of better quality. Similar results have been obtained by crossing Gaddi breed of sheep with Rambouillet rams in Himachal Pradesh.

Poultry

Co-ordinated research projects for developing high egg and meat producing poultry strains have also been taken up. The project on poultry for eggs has been sanctioned for four centres which have been established during 1970-71. The object of this project is to develop a strain of poultry with high production potential in order to meet with the demand of commercial chicks and obviate the need for import of birds and payment of royalties for such birds which are at present being marketed by poultry farmers with foreign collaboration. This project envisages testing of 25 high egg laying strains at a time which involves maintaining 1500 layers of each strain. A large number of breeding pens for testing sires (100 in each strain) are required. The work of this dimension has not been attempted in the country in the past. In order to meet this requirement, facilities are being created at different centres. The construction of breeding pens at Jabalpur has been completed and at Hyderabad it is nearing completion. Plans for construction of poultry pens at IVRI have been finalised and work is to be started during 1972-73. At Mathura the existing buildings are being remodelled for the project. Screening of high-producing strains available within the country has been made and already six strains capable of laying more than 200 eggs per bird per year have been selected and are being raised at the four centres. In addition exotic strains have been imported. It is expected that it will be possible to select the desirable strains during the Fourth Five-Year Plan.

The project on poultry for meat is in operation at four centres at Izatnagar, Bangalore, Madras and Bhubaneswar. Under these projects it is envisaged to develop a broiler (meat producing bird) which may weigh 1½ kg at 10 weeks of age. At the Bangalore and Izatnagar centres which have been doing work on these lines prior to initiation of this project work on three strains available in the country is being done. It has been possible to produce a broiler weighing over 1 kg in 10 weeks with six strains of 3 breeds maintained at Izatnagar and Bangalore. The Bangalore strain has been found to be superior. The material from both centres is being pooled and supplied to the four centres for taking up the programme. The housing facilities for this programme have been created. At IVRI 128 breeding pens have been built. At Bhubaneswar also the buildings are ready. At Bangalore additional pens have been provided and at Madras an existing state farm has been allotted for this work. The programme under this project has advanced to the extent the facilities have become available. Four exotic strains have been imported. It is expected that with the available material it may be possible to test the various strains during the Fourth Five-Year Plan.

Goats and Pigs

Co-ordinated projects on goats for milk and Mohair production have been recently sanctioned and suitable action is being taken to implement these programmes.

Pigs are known to be prolific breeders with a capacity for efficient feed conversion. The indigenous pigs are however low producers. A project to develop through cross breeding pigs having early maturity and efficient feed conversion has been taken up at 5 centres. Under this the heritability of various characters of pigs maintained at optimum conditions will be studied and breeds suited to various agro-climatic conditions would be evolved. The programme also envisages investigation of the effect of protein energy ratio on production of pigs. The work under this project has been initiated at the different centres.

Animal Nutrition

With a view to mitigating shortage of livestock feeds through better utilisation of existing resources and by finding new sources of feeds, investigations on use of agricultural by-products and industrial waste material are being conducted under co-ordinated project at 4 centres. In addition, work is also in progress at IVRI and NDRI on this subject.

Considerable progress has been made under these projects. At Anand it has been possible to incorporate Cassitora seeds to the extent of 15 per cent in the concentrate feed of livestock both for growth and milk production. By-products like tomato waste and mango seed kernels have also been successfully incorporated in the ration. At Pantnagar, a complete ration using wheat straw treated with alkali and enriched with urea molasses has been prepared. The ration has been found suitable for growing stock. Experiment on milk production are in hand. An automatic huller for mango seeds has been designed at this station. At Bhubaneswar investigations have been completed on raising of pigs on sal seed meal. Preliminary investigations are also completed on utilisation of this material for milk production. At Trichur tapioca leaves have been found to contain up to 30 per cent protein and it has been possible to replace groundnut cakes with this material in the ration for growing calves as well as milch cattle. Work has also been completed on pigs using tapioca leaves as source of protein. Preliminary investigations have been completed on feeding of rubber seed cake to pigs. There is need for general adoption of some of the items through pilot studies.

Animal Health

With a view to ensuring healthy condition of animals intensive research to advance knowledge in respect of incidence, etiology, epidemiology, mode of separating major livestock diseases and their control is being carried out under the coordinated projects and at the central Institutes. The foot and mouth disease which is of great economic importance particularly in relation to cross-breeding programmes is being investigated under a coordinated project. A comprehensive project to study the epidemiology of this disease has been sanctioned in 1971 and has been initiated at 8 centres. A project on Typing of Foot and Mouth disease virus which was functioning at 4 centres has been merged with this. In addition to detailed epidemiological studies typing work will continue under this project. The viruses of Foot and Mouth disease is are known to exist in several distinct immunological farms and a successful vaccination programme against the disease requires an intensive study of the pattern of the disease in different parts of the country. This project is expected to provide suitable information which would be useful not only for production of Poly-valent vaccine but also to give indication about the pattern of vaccination which should be adopted.

Another co-ordinated project to study the factors responsible for calf mortality in different parts of the country is in operation at four centres. The object of this is to determine the factors which are responsible for mortality among calves and attempt to develop and apply quicker diagonostic technique to have effective preventive measure and reduce the mortality.

Similar coordinated projects to study the etiology of Stephnofilariasis and Nasal Schistosomiasis have been taken up at different centres and in both these useful information in regard to live cycle and trail of some drugs for prevention and control have been obtained.

With a view to determining the incidence of various respiratory infections of poultry in the country and to identify the etiological agents together and to develop quicker and simpler diagnostic tests and also to evolve suitable prophylactic and control measures, a coordinated research project on respiratory diseases of poultry has been taken up at five centres, namely IVRI, Izatnagar, Mathura, Jabalpur, Madras and Bubaneswar. Seriological surveys under different centres had clearly shown that all the three infections, namely IB, ILT and PPLO are prevalent throughout the country. Comparatively, the infections of IB and ILT appear to be less common in southern parts of the country. A significant advance made in the project was at the IVRI centre where it was possible to develop a PPLO antigen which gave comparable results with imported antigen. This centre undertakes now production of this antigen for use by different centres. The IVRI centre also prepared first batch of IB vaccine utilising Mathura strain at the 19th serial passage in embryonated eggs. Research under this will have to be further intensified to develop vaccine with indigenous strains against ILT, IB and other associated respiratory infections which are coming to light as a result of research under this project.

Dairying

A number of co-ordinated studies on different aspects of dairying have been taken up during the Fourth Five-Year Plan with a view to improving production of milk products and study the economics of milk production. One of these projects relates to the economics of milk production under intensive dairy farming conditions in relation to high-yielding varieties of cereals and cash crops. This project is in operation at 9 centres under different agroclimatic conditions. These are Agricultural Universities at Jabalpur, Hyderabad, Hissar, Rahuri, Patna and Udaipur and Government Farm, West Bengal, Allahabad Agricultural Institute and the I.G. F.R.I., Jhansi.

Under this project comparative cost of milk production under different systems of farming mentioned

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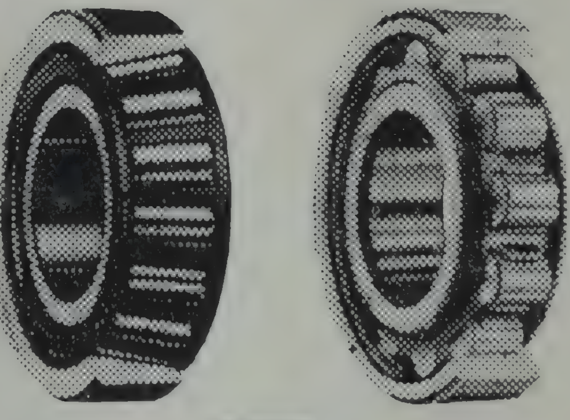

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in the project are to be compared. It is hoped that as a result of this study it will be possible to determine conditions under which commercial dairy farming can be taken up and milk can be produced as the main crop rather than as a by-product. The studies are in progress.

The second project relates to a study of the technological and economic problems of operation in liquid milk plants. The project has a coordinated unit at the NDRI and has research units at Delhi Milk Scheme, Worli Dairy Bombay, Milk Plant Chandigarh, University of Udaipur, Udaipur, Lucknow Dairy and NDRI.

Under this project important economic and technological problems met with in the liquid milk plants after receipt of milk to its distribution are to be studied. The scheme is sanctioned for 3 years with a view to getting results which can be passed on to the industry for utilization.

The third project relates to a study of cost of chilling and transportation of milk to city dairies. The project has for its object a study of important problems relating to the collection of milk from the producers and its processing, transportation, etc. up to its arrival at the milk plant. The coordinated unit is located at NDRI and the research units at Cuttack, Jabalpur, Hyderabad, Jammu, Gauhati and Hissar. The project has been started recently and at most of the centres preliminary steps have been taken to establish the research facilities.

The fourth project relates to a study of economic methods for the utilisation of surplus/sub-standard milk. Under this scheme a study is made of the most economical and profitable manner in which seasonal surplus and sub-standard milk which has very often to be received at milk plants can be utilised so that the minimum amount of milk is wasted as human food and the best returns are obtained. The project has a coordinating unit at NDRI, Karnal with 9 research units at Harringhatta, Vijayawada, Bangalore, Mehsana, Chandigarh, Patna, Bombay, Cuttack and Allahabad. These nine units are divided into three groups of small, medium and large dairies so that results of the studies will be applicable to dairies of similar size. The technical programme includes work on indigenous products as well.

Animal Product Technology

Prior to the Fourth Five-Year Plan little attention was paid to research on Animal Products Technology with the result that the farmers were not getting maximum returns for the products and also large quantities of the products were being left unutilized. In order to tackle the various priority problems coordinated studies are being made on under-mentioned projects:—

(a) Utilization of slaughter house by-products;

(b) Studies on technological problems in commercial production of dressed poultry and piggery products;

(c) Canary colouration of Indian wools;

(d) Manufacturing trials on graded wools.

Fisheries

Fisheries research during the Fourth Plan period is largely being looked after by the three Central Fisheries Institutes, one each for marine fisheries, inland fisheries and fisheries technology. Some of the States also have been tackling a few research problems concerning them, but these have been on a limited sphere. Besides these, the ICAR had initiated during this period seven all-India Co-ordinated research projects. The position and general progress during this period is summarised below.

Seven All-India Co-ordinated Research Projects in Fisheries were initiated during this plan period. Of these, four deal with various aspects of inland fisheries, one on marine prawn biology and resources and two with fish technology. The inland fisheries projects concern with the carp spawn prospecting in the major river systems of the Ganga and Hooghly, the study of the fisheries of the freshwater reservoirs, problems in composite culture of Indian and exotic fishes so as to improve production in ponds and propagation of air-breathing fishes in swampy areas where these could be successfully cultured. The fish technology projects deal with the ways of effective utilisation of the large quantities of uneconomic fish that are invariably waste in commercial fishing operation and also how best to transport fish in fresh condition through improved containers and other means. All these projects commenced operation during the latter half of 1971 and the current plan period will largely be devoted to obtaining basic information after settingup the various centres. The results thus obtained will serve for more effective planning and execution of these projects during the next plan period.

Broad appreciation of major problems in the implementation of Animal Science Research Programmes

Although work under all the coordinated projects in Animal Sciences has been initiated and in some of the projects considerable progress has been achieved, the level of exenditure and the achievements in completion of technical programme has been somewhat slow due to various reasons important among these are discussed below:

(a) Out of 32 coordinated projects nearly 22 projects were finally cleared and sanctioned in the the latter part of 1970, and early 1971. As such these could start only late in the Plan period.

(b) Slow pace of progress of construction works for experimental animals by CPWD.

(c) Most of the breeding projects require import of exotic stock for which there has been delay in release of foreign exchange and in finally arranging of import of animals.

(d) In some cases procedural delay in the recruitment of scientific staff have been experienced.

AGRICULTURAL EDUCATION AND MANPOWER

The utilisation position has been quite satisfactory in case of first four schemes which were cleared through E.F.C. well in time. Scheme No. 5 started functioning only during 1971-72 and others are yet to start. Until 1969-70, assistance to agricultural universities and colleges was given on the UGC pattern. The revised pattern under which assistance is now given on 100% basis for 16 specific items has come into force during 1970-71. The colleges received assistance for 11 items only. The ceilings in the case of agricultural universities post-graduate colleges and under-graduate colleges are Rs 200 lakhs, Rs 8 lakhs respectively. By now, all major states except Jammu and Kashmir have an agricultural university. Agricultural Universities in Kerala, Gujarat, Tamil Nadu and Himachal Pradesh have started only recently. The state of Jammu and Kashmir is likely to start an agricultural university in 1972-73.

The major emphasis in programmes of agricultural education is on improvement of standards and quality of education, consolidation of post-graduate education, orientation of curricula and courses to suit the needs of agricultural development, development of inter-institutional collaboration and centres of excellence. Further efforts are being made to attract better students and research workers to the agricultural system. Science talent search scholarships, Jawaharlal Nehru awards and the post-doctoral fellowships have been initiated with this specific objective. The scheme for improvement of teaching faculty competence has yet to come into operation. Assistance is also being directed to develop new programmes of higher education, for example, in the field of food technology, human nutrition, communication, water technology, fisheries, etc.

While the number of agricultural universities have almost doubled during the past two years, the outlay has been insufficient to meet the needs of their development. During the Fifth Plan period, it would be necessary to ensure that each University develops a well thought out plan of academic and campus development and works out the needs of technical assistance. It would be necessary then to provide adequate funds to enable the new Universities to come to an effectively functional stage. Special concessions may have to be made in the case of agricultural universities which are likely to receive World Bank assistance for their development during the last two years of the Fourth Plan and during the Fifth Plan. It is obvious, therefore, that the total outlay for agricultural universities will have to be much larger during the Fifth Plan compared to Fourth Plan period. Likewise, if agricultural education is to be at par with other technical education, the outlay of fellowships and scholarships will have to be enhanced suitably to attain comparable coverage of students with fellowships and scholarships. Provisions will have to be made for advance training abroad. A vigorous programme of technical assistance to friendly developing countries will also have a priority in programmes of agricultural education. Preparation of text books and teaching aids needs to be stepped up in a systematic manner. Much greater emphasis will have to be given to the programmes of students welfare, students amenities and teachers welfare. Agricultural universities will have to develop manpower planning cells in collaboration with the respective State Governments in order to place planning of agricultural education on a sound footing. Regional planning will have to be given more attention than it has received in the past. Agricultural institutions will have to develop programmes involving work experience, practical training, apprenticeship, etc. to inculcate confidence amongst students and to make them not only more 'employable but also capable, of earning their living through 'self-employment'. Periodic evaluation of performance would be an inescapable activity that educational institutions will have to undertake if resources are to be utilised efficiently. Pressures on colleges and universities will have to be relieved by creating facilities for 'middle level training' and vocational education. The scheme of agricultural polytechnics is intended to be implemented with this objective during the Fifth Plan period.

Manpower In Agricultural Education

There are at present 73 agricultural colleges and 22 veterinary colleges, two dairy colleges and 8 agricultural engineering colleges offering courses in various fields of agriculture, animal sciences, agricultural engineering, etc. Most of these colleges have now come under the agricultural universities in existence at present. The intake and output to the various faculties are indicated below—

Year 1968-69 :	*Under graduates*		*Post-graduates*	
	Intake	*Output*	*Intake*	*Output*
(1) Agricultural colleges	8542	581	1704	1632
(2) Vety. and Animal Husbandry colleges	1167	1076	312	192
(3) Agrl. Engineering	250	230	60	40

It is estimated that there will be a surplus of about 9,000 agricultural graduates and 4660 post-graduates by the end of the Fourth Plan period. In case of veterinary science, the surplus would be of the order of 1915 graduates and 600 post-graduates by 1973-74. In the field of agricultural engineering, about 700 graduates may remain unemployed at the end of the Fourth Plan. Thus, by the end of Fourth Plan about 16,000 graduates and post-graduates are expected to go without jobs in these three disciplines.

During the Fifth Plan period the output of agriculture, veterinary and agricultural engineering graduates is estimated at 40,000, 4,200 and 1,400 respectively.

Although the expansion in the form of individual colleges has come to a stop in the wake of ICAR's current policies, expansion of agricultural education is assuming a different form lately. Some of the states which have started agricutural universities, have decided to develop main campus of the universities at a new site altogether. This tendency needs to be curbed. Also new avenues of employment and career opportunities will have to be created for agricultural graduates and post-graduates. This would include not only farm employment *per se*, but also agro-industries, rural banking, supporting services, inputs services, agricultural extension and schemes for self-employment. Centre-State and Universities will have to do not only for the public sectors where estimates are more reliable and definite but also for private sector where job opportunities have been appearing increasingly lately and which is likely to be the largest employer of technical manpower eventually. It would appear that with the present intake capacity at agricultural, veterinary and agricultural engineering colleges together with the existing stock of unemployed graduates and post-graduates, there would be no need for 'expansion' of agricultural programmes in terms of numbers of institutions or admissions during Fifth Plan period and the needs (including new needs) that emerge can be fully met with the existing resources. The emphasis, however, needs to be given on quality and excellence, practical work experience, skills, techniques and relevance of programmes to the newly emerging needs. Thus, there would be the real challenge, during the 'Seventies' in the field of agricultural education.

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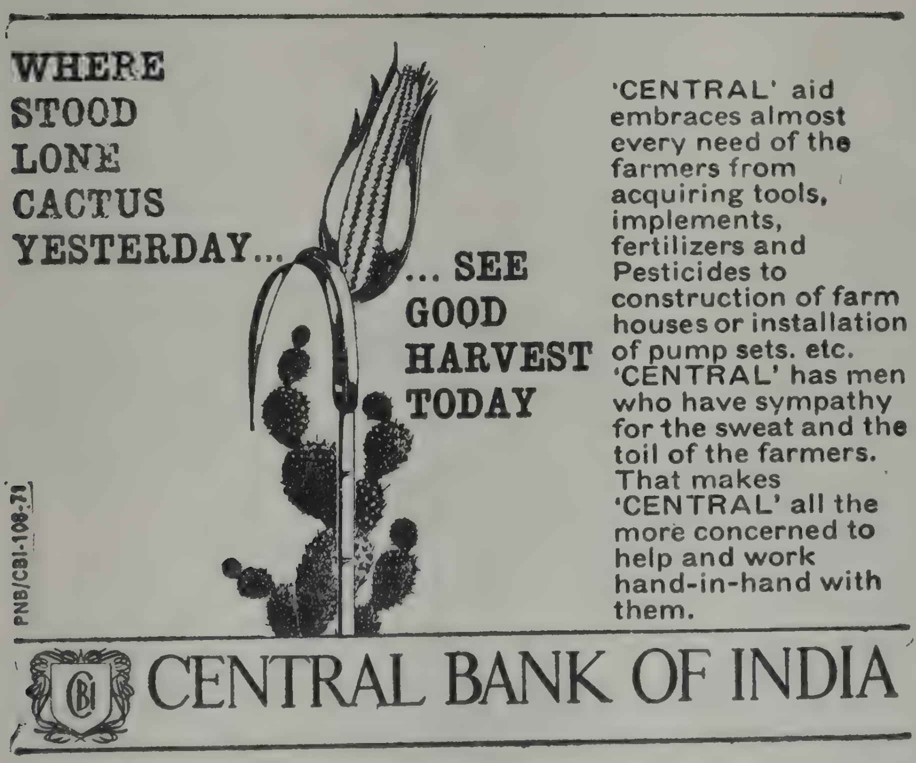
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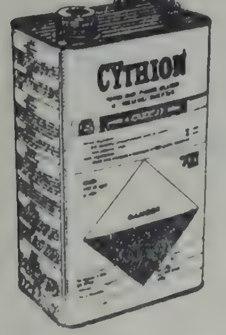

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